Study on the Implications of Asynchronous GMO Approvals for EU Imports of Animal Feed Products

Contract N° 30-CE-0317175/00-74

Executed on behalf of

Directorate-General for Agriculture and Rural Development
European Commission

Undertaken by

Agricultural Economics Research Institute (LEI) – Wageningen UR
(Lead Contractor)

Economics and Management of Agrobiotechnology Center (EMAC) – University of Missouri

Plant Research Institute (PRI) – Wageningen UR

Final Report

December 2010

LEI WAGENINGEN UR

EMAC

Authors

Agricultural Economics Research Institute (LEI) – Wageningen UR

Peter Nowicki (Study Leader)
Lusine Aramyan
Willy Baltussen
Leo Dvortsin
Roel Jongeneel
Ignacio Pérez Domínguez
Coen van Wagenberg

Economics and Management of Agrobiotechnology Center (EMAC) – University of Missouri

Nicholas Kalaitzandonakes
James Kaufman
Douglas Miller

Plant Research Institute (PRI) – Wageningen UR

Linus Franke
Bastiaan Meerbeek

The members of study team would like to acknowledge their appreciation to the Steering Group, and in particular to Manuel Gómez-Barbero, the Technical Officer, for the rigorous critical examination of the different parts of this study. Any error or short-coming remains, nevertheless, the responsibility of the authors.

Table of Contents

Figures

Tables

Box

Abbreviations

AP	Adventitious presence
bln t	Billion metric tons
Bt	Bacillus thuringiensis
CAP	Common Agricultural Policy
CAPRI	Common Agricultural Policy Regionalised Impact modelling system
CGE	Computable general equilibrium (model)
CGF	Corn gluten feed
CIF	Cost, insurance and freight
COCERAL	Comité du Commerce des cereals, aliments du bétail, oléagineux, huile d'olive et graisses et agrofournitures
DG AGRI	Directorate-General for Agriculture and Rural Development
DNA	Deoxyribonucleic acid
EFSA	European Food Safety Agency
EU	European Union
EU-10	Ten new Member States of the European Union from May 2004
EU-12	EU-10 plus Bulgaria and Romania
EU-15	Fifteen Member States of the European Union from May 2004
EU-25	Twenty-five Member States of the European Union from May 2004
EU-27	EU-25 plus the 2006 Accession Countries (Romania and Bulgaria)
FAO	Food and Agriculture Organisation
FAPRI	Food and Agricultural Policy Research Institute
FeedMod	'Feed model' developed by Tallage Policy Research Institute
FEFAC	Fédération Européene des Fabricants d'Aliments Composés
FOB	Free on board
GDP	Gross Domestic Product
GM	Genetically modified
GMO	Genetically modified organism
GTIS	Global Trade Information Services
IP	Identity preservation
IPR	Intellectual property rights
LLP	Low level presence
LP	Linear programming
mln t	Million metric tons
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PCR	Polymerase chain reaction
PE	Partial equilibrium (model)
t	Metric ton
T-J	Takayama-Judge (model)
TRQ	Tariff Rate Quota
USA	United States of America
USDA	United States Department of Agriculture
WTO	World Trade Organisation

Glossary

The subject of GMOs is complex, and the reader may wish to examine general explanations of the technical terms (like event, trait, transgene, etc.). Please refer to the following glossaries that are freely accessible online[1].

The glossary of Co-Extra (a project of the European Commission’s 6th Framework Programme) at
http://www.coextra.eu/glossary/

FAO's list of terms and acronyms in applied biotechnology at
http://www.fao.org/biotech/index_glossary.asp

The agricultural biotechnology glossary of the USDA's Economic Research Service at
http://www.ers.usda.gov/Briefing/Biotechnology/glossary.htm

The Canadian Food Inspection Agency's definition of commonly used terms in biotechnology at
http://www.inspection.gc.ca/english/sci/biotech/gen/terexpe.shtml

The glossary of the portal on GMO Safety (supported by the German Ministry of Research) at
http://www.gmo-safety.eu/en/glossary/

The glossary of the GMO-Compass at
http://www.gmo-compass.org/eng/glossary/

Monsanto's biotechnology glossary at
http://www.monsanto.com/biotech-gmo/asp/glossary.asp

---

[1] This list of on-line glossaries is presented in Stein and Rodríguez-Cerezo (2009).

1 Introduction, analytical framework and methodology

Peter Nowicki

1.1 Introduction

1.1.1 Purpose of the study

The aim of this study is to understand the implications of asynchronous approvals for genetically modified organisms (GMOs) that are imported to the European Union (EU) for use within animal feed products, specifically with regard to the EU livestock sector, as well as upon the upstream and downstream economic industries related to it. Asynchronous approval refers to the situation in which there is a delay in the moment when a genetically modified (GM) event – modifying a specific trait of a plant or animal – is allowed to be used in one country in comparison to another country. In the perspective of this study, the asynchronous GMO approvals concern the use of GM varieties of plants that are approved in the countries which supply them to the EU, in one form or another of feed material, before these are approved by the EU.

Not all the ingredients for livestock feed used in the EU, either prepared by commercial firms or on-farm, are solely sourced within the EU market. Among the imported ingredients are maize and soybeans, and products derived from them. These two plants are increasingly subject to genetic modification to enhance their agronomic and/or phenotypic qualities. Some of these qualities are generic enhancements (tolerance to a widely marketed herbicide) and some are regionally important (resistance to a specific pest), and thus a wide variety of GM events are becoming available around the world, as will be explained in a following section.

The EU must first approve all new GM events that are intended for import in a process that involves the European Food Safety Agency (EFSA), EU Member States (MS) and the European Commission. The approval procedure requires screening by the EFSA and approval by the responsible authorities.

Much research is required to develop and test new GM events, and not all are eventually commercialised. The range of GM events under research and development, in the course of approval or scheduled for release for commercial use are all part of the GMO pipeline. In addition to the GM events that are commercialised, there are also those which have been developed, tested and then abandoned in commercial terms, but which may still be present in the environment. The quantity of GM events is increasing rapidly, as is highlighted in the literature reviewed below.

A first consideration important for this study is that GM material not approved by the EU may be commingled[2] with approved material along the supply chain from a

---

[2] Commingling refers to the admixture of small amounts of different material.

foreign farm to the port of entry to the EU. According to EU legislation, no trace of unapproved GM material (referred to as zero tolerance) is acceptable. In this case, there is a risk of an incident of supply disruption of livestock feedstuff to the EU.

A second consideration important for this study is that asynchronous GMO approval of GM material used for livestock feed could result in a long-term, or permanent, disruption of trade of livestock feed material to the EU from one or more countries currently providing these supplies. Of particular concern in this regard is the provision of maize and soy, as there are relatively few countries supplying most of the material imported not only by the EU, but around the world. Alternative sources of supply may be insufficient to replace GM feed material now coming from the current group of countries supplying this material.

This study examines the possibility of countries now supplying livestock feedstuff to continue to do so both in the short term (2012) and the long term (2020), in relation to the potential for asynchronous GMO approval; the study builds upon the investigation of other studies reviewed hereafter, in regard to two situations. One situation is when there are small amounts of commingled unapproved GM material within the supply chain (referred to as Low Level Presence: LLP). A second situation is when prolonged or permanent asynchronous GMO approval leads to a structural breakdown in bi-lateral trade. The study also examines the impact of a disruption in imported livestock feed material at the level of EU Member States; in this regard, the possibility for substitution of livestock feedstuff is also taken into account.

1.1.2 Authorisation procedure for GMO events

The EU authorisation procedure for GM plant material combines both scientific and political stages.

Regulation (EC) No 1829/2003[3] introduces a centralised authorisation procedure of GM food and feed, which is based on an independent risk assessment carried out by the European Food Safety Authority (EFSA). The authorisation procedure is briefly outlined below (Regulation (EC) No 1829/2003, European Commission 2010a):

1. *Submission of an application*. The company wishing to place a GM food or feed on the European market files an application and sends it to the competent authority at national level. The national authority acknowledges the receipt of the application and directly passes it to EFSA.
2. *Preparation and delivery of an opinion by EFSA*. EFSA undertakes a scientific evaluation and shall forward its opinion within six months of receiving the application to the Commission. The time limit is extended if additional data is requested during the scientific assessment (which is regularly the case). (Applications are also forwarded to the European Commission and to the Member States, who are consulted on the application over a 3 month period.)[4]

---

[3] Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed, Official Journal L 268, 18.10.2003.

[4] The general public may comment on the overall EFSA opinion within 30 days of its publication. The EC analyses the received comments and consults EFSA to determine whether they have an impact on its opinion.

3. *Preparation and adoption of a Decision*. Within three months after receiving the EFSA opinion, the Commission shall submit a draft Decision to the Standing Committee of Food Chain and Animal Health. If the Standing Committee accepts the proposal, it is adopted by the Commission. Alternatively, it is passed on to the Council of Agricultural Ministers. The Council has a time limit of three months to reach a qualified majority for, or against, the proposal. If it is unable to reach a vote with a qualified majority, the proposal is passed back to the EC which then adopts the proposal (Davison 2010)**.**

Following the procedure outlined above, the authorisation for GMO import could theoretically be granted within nine to ten months after application (six months for the EFSA opinion and three months for the draft decision of the EC). Taking into account additional data requirements, step 2 (EFSA opinion) is usually prolonged to two years and the political decision making in step 3 is prolonged for another year, so that the typical duration from first application to the final decision is about three years. Even much longer authorization procedures have sometimes been observed (the application for approval of Monsanto's MON863 x MON810 maize was filed in July 2004, whereas the final authorization took place in March 2010) (European Commission 2010b, GMO Compass 2010).

According to Regulation (EC) No 1829/2003 and Regulation (EC) No 1830/2003[5], food and feed containing more than 0.9 per cent EU authorised GMOs must be labelled as such. Since 2007, the tolerance threshold for unapproved GM events in the EU is zero. In practice this means the threshold equals the detection level, which is commonly agreed to be around 0.1 per cent (Fischer Boel, 2009). Between 2004 and 2007, the transitional Article 47 of Regulation (EC) No 1829/2003 enabled the presence of unapproved GMOs whose presence was considered adventitious or technically unavoidable and which had benefited from a positive evaluation by the Community Scientific Committee or the Authority before the coming into effect of this regulation. The relevant threshold level has been 0.5 per cent.

1.1.3 Main exporters and importers of maize and soy on the world market

The evolution of maize and soy production, and the evolving structure of the world markets, is described in detail in Chapter 3, but Table 1.1 gives an overview of the production, export and import of maize, soybean and soymeal on the world market for the period between 2006/2007 to 2009/2010 (in terms of trade years) so that the reader will see that the exporting countries retained for specific examination in this study are the major agents in the world trade market for these commodities.

---

[5] Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC, Official Journal L 268, 18.10.2003.

Table 1.1: World maize, soybean and soymeal production, exports and imports, 2006/2007 to 2009/2010, in mln t, with principal producers, exporters and importers

	World Maize Production			
	2006/07	2007/08	2008/09	2009/10*
Argentina	22,500	22,017	15,000	22,500
Brazil	51,000	58,600	51,000	56,100
Canada	8,990	11,649	10,592	9,561
China	151,600	152,300	165,900	155,000
EU-27	53,829	47,555	62,321	56,548
Serbia	6,415	4,054	6,130	6,400
Ukraine	6,400	7,400	11,400	10,500
United States	267,503	331,177	307,142	333,011
Others	145,214	158,863	168,353	161,350
World Total	713,451	793,615	797,838	810,970

	World Soybean Production			
	2006/07	2007/08	2008/09	2009/10*
Argentina	48,800	46,200	32,000	54,500
Brazil	59,000	61,000	57,800	69,000
Canada	3,466	2,696	3,336	3,500
China	15,967	14,000	15,540	14,700
India	7,690	9,470	9,100	8,750
Paraguay	5,856	6,900	4,000	7,200
United States	87,001	72,859	80,749	91,417
Others	9,346	7,881	9,439	10,825
World Total	237,126	221,006	211,964	259,892

	World Soymeal Production			
	2006/07	2007/08	2008/09	2009/10*
Argentina	26,061	27,071	24,363	26,080
Brazil	24,110	24,890	24,700	25,790
China	28,465	31,280	32,475	38,525
EU-27	11,550	11,715	10,131	9,848
India	5,176	6,705	5,746	5,460
Mexico	3,075	2,814	2,727	2,760
United States	39,037	38,359	35,473	37,671
Others	16,297	15,707	15,818	17,624
World Total	153,771	158,541	151,433	163,758

	World Maize Exports			
	2006/07	2007/08	2008/09	2009/10*
Argentina	15,693	15,676	8,458	15,500
Brazil	8,071	7,883	7,178	7,500
EU-27	664	591	1,743	1,400
Paraguay	1,981	1,461	1,862	1,000
Serbia	854	128	1,467	1,500
Ukraine	1,027	2,074	5,497	5,000
United States	54,214	60,663	47,758	50,000
Others	8,970	9,789	9,990	6,930
World Total	91,474	98,265	83,953	88,830

	World Soybean Exports			
	2006/07	2007/08	2008/09	2009/10*
Argentina	9,560	13,839	5,590	11,500
Brazil	23,485	25,364	29,986	28,450
Canada	1,683	1,753	2,017	2,200
Paraguay	4,361	5,400	2,637	5,400
United States	30,386	31,538	34,817	40,687
Others	1,840	1,695	2,206	2,603
World Total	71,315	79,589	77,253	90,840

	World Soymeal Exports			
	2006/07	2007/08	2008/09	2009/10*
Argentina	25,625	26,816	24,025	25,380
Brazil	12,715	12,138	13,109	12,500
China	867	634	1,017	1,250
India	4,143	5,285	3,808	2,750
United States	7,987	8,384	7,708	10,342
Others	3,281	2,907	3,150	3,058
World Total	54,618	56,164	52,817	55,280

	World Maize Imports			
	2006/07	2007/08	2008/09	2009/10*
China	16	41	47	1,300
EU-27	7,056	14,016	2,743	2,500
Others	84,402	84,208	81,163	85,030
World Total	91,474	98,265	83,953	88,830

	World Soybean Imports			
	2006/07	2007/08	2008/09	2009/10*
China	28,726	37,816	41,098	50,000
EU-27	15,291	15,123	13,213	12,900
Others	25,049	25,179	22,857	24,232
World Total	69,066	78,118	77,168	87,132

	World Soymeal Imports			
	2006/07	2007/08	2008/09	2009/10*
EU-27	22,213	24,074	20,980	21,800
Others	30,334	29,995	30,204	31,411
World Total	52,547	54,069	51,184	53,211

*2009/2010 figures are estimates in most cases

Source: USDA-FAS, 2010a and 2010b

Aside from soybeans, soymeal and maize, other bulk agricultural commodities used as livestock feedstuff are wheat, rapeseed and rapeseed meal (Table 1.2). With regard to GM events, GM maize and soy are the principal crops under study because of the considerable importance of their planting worldwide. GM rapeseed is mainly planted in Canada and the USA, but is only 21% of world production in 2009 (GM Compass, 29.11.2010); and the commercialization of wheat is some 10 years away (Reuters, 08.06.2010). Although the production area of rapeseed is limited, GM rapeseed commingling could take place in shipments from these countries to the EU (therefore there is an LLP risk). The research into GM wheat might result in the adventitious presence of GM material in crops harvest around the testing areas of GM wheat varieties. These circumstances are a reason to consider the possibility of LLP risk as very slight for rapeseed or wheat in the timeframe of this study, rather than to consider that either rapeseed or wheat might not be available on the world market as possible substitute feed ingredients for either maize or, principally, soy.

Table 1.2: Global production and exports of wheat, rapeseed and rapeseed meal, trading years 2004/2005 to 2009/2010*, in mln t

	Wheat		Rapeseed		Rapeseed Meal	
	Production	Exports	Production	Exports	Production	Exports
2004/05	626.7	113.9	46.09	4.90	24.22	2.24
2005/06	619.2	114.1	48.51	6.98	26.55	2.51
2006/07	596.1	115.6	45.09	6.62	25.91	2.96
2007/08	611.2	116.4	48.51	8.12	27.64	3.69
2008/09	683.3	143.3	57.92	12.02	30.80	3.55
2009/10	680.4	134.1	59.93	10.68	33.60	3.51

* estimate for 2009/2010
Source: USDA-FAS, 2010a and 2010b

Although the EU is not a major world producer of soybean, it is a major producer of wheat and maize. There is export and import of maize not only between the EU and the world market, but also between the EU Member States. Considering net trade of the EU MS in terms of total non-EU import and export, Table 1.3 gives an overview of the dependency on foreign imports. Although the EU is a major producer of maize, the logistics of trade may mean that a particular Member State would be in a more difficult situation to adjust to a supply disruption from one or another of the non-EU countries exporting maize to the EU.

Table 1.3: Net trade of EU Member States for maize in metric tons (including intra-EU), % imports from non-EU and % exports to non-EU

Region	2005			2006			2007			2008			2009		
	net trade	im	ex	net trade	im	ex	net trade	im	ex	net trade	im	ex	net trade	im	ex
Austria	121,379	3%	5%	90,757	1%	2%	64,097	0%	3%	233,019	1%	2%	53,890	1%	1%
Belgium - Luxemburg	-413,721	1%	0%	-413,953	17%	0%	-651,773	34%	0%	-684,972	34%	0%	-471,280	1%	0%
Denmark	-74,217	2%	67%	-87,035	6%	34%	-99,212	21%	46%	-362,814	66%	9%	-98,292	12%	74%
Finland	-246	64%		-2,199	7%		-3,285	6%		-3,379	3%	67%	-251	80%	
France	7,147,056	6%	1%	5,849,901	10%	1%	3,852,740	55%	3%	5,725,955	29%	6%	6,381,063	6%	3%
Germany	-846,321	0%	2%	-984,764	2%	2%	-1,727,375	18%	3%	-1,596,581	25%	3%	-1,276,446	0%	2%
Greece	-213,881	4%	0%	-468,406	26%	10%	-638,754	23%	32%	-439,048	76%	15%	-82,906	27%	6%
Ireland	-158,361	1%	0%	-193,261	1%	0%	-234,744	28%	0%	-400,785	27%	0%	-330,743	0%	0%
Italy	-1,249,254	18%	12%	-1,643,066	21%	7%	-2,438,880	23%	5%	-2,116,357	34%	40%	-2,089,370	14%	15%
Netherlands	-2,238,070	5%	1%	-2,422,877	8%	0%	-3,225,369	25%	2%	-3,430,161	25%	2%	-2,847,528	6%	4%
Portugal	-1,218,293	50%	1%	-1,293,737	66%	2%	-1,666,927	86%	0%	-1,575,062	81%	2%	-1,339,534	32%	9%
Spain	-4,285,385	40%	1%	-4,218,505	49%	1%	-6,611,558	78%	1%	-5,307,989	66%	5%	-3,932,244	32%	0%
Sweden	-5,583	15%	21%	-10,490	7%	94%	-16,257	38%	93%	-37,594	4%	97%	-10,927	13%	94%
United Kingdom	-1,321,658	4%	0%	-1,098,770	13%	32%	-1,386,990	35%	0%	-1,042,174	38%	0%	-885,083	21%	0%
EU-15	-4,756,555	20%	1%	-6,896,405	27%	1%	-14,784,287	47%	3%	-11,037,942	45%	5%	-6,929,651	16%	3%
Cyprus	-155,155	42%		-148,972	68%		-189,265	40%		-166,598	83%	87%	-172,157	27%	
Czech Republic	73,993	2%	1%	227,705	2%	0%	115,874	1%	0%	202,471	5%	0%	412,590	7%	0%
Estonia	-17,713	2%	0%	-10,865	0%	0%	-13,770	16%	0%	-30,883	54%	0%	-12,799	54%	0%
Hungary	1,876,169	41%	3%	2,358,277	26%	2%	5,047,302	8%	4%	3,341,337	24%	6%	4,130,840	41%	2%
Latvia	-2,291	8%	4%	-8,157	4%	5%	-8,298	12%	4%	-46,067	72%	0%	-3,843	68%	4%
Lithuania	-21,798	1%	9%	-22,681	0%	0%	-45,101	13%	6%	-116,164	98%	1%	-19,754	50%	0%
Malta	-61,620	10%		-45,707	0%		-64,731	45%	0%	-68,877	91%	0%	-53,109	58%	
Poland	248,766	3%	0%	36,970	1%	1%	-473,541	0%	0%	-754,299	27%	0%	-148,757	2%	1%
Slovak Republic	69,772	1%	0%	601,210	0%	0%	111,936	0%	0%	-8,435	1%	0%	248,153	2%	0%
Slovenia	-112,471	8%	1%	-151,693	20%	0%	-214,197	13%	3%	-111,436	21%	0%	-75,914	35%	2%
EU-10	1,897,652	19%	2%	2,836,087	21%	1%	4,266,209	11%	4%	2,241,049	39%	5%	4,305,250	20%	2%
Bulgaria							-17,890	31%	46%	-6,337	28%	39%	461,161	75%	27%
Romania							-355,817	39%	53%	173,663	6%	73%	873,182	6%	43%
Bulgaria/Romania							-373,707	37%	50%	167,326	12%	65%	1,334,343	14%	39%
EU-15	-4,756,555	20%	1%	-6,896,405	27%	1%	-14,784,287	47%	3%	-11,037,942	45%	5%	-6,929,651	16%	3%
EU-25	-2,858,903	20%	1%	-4,060,318	26%	1%	-10,518,078	45%	3%	-8,796,893	45%	5%	-2,624,401	16%	2%
EU-27							-10,891,785	45%	5%	-8,629,567	44%	9%	-1,290,058	16%	7%
Note: '+' = Net exportor; '-' = Net importer															

Note: '+' = Net exporter; '-' = Net importer
The column 'net trade' is export minus import
'im' is the % of non-EU import in relation to total import (world, including EU)
'ex' is the % of non-EU export in relation to total export (world, including EU)
Source: EUROSTAT

This study is also specifically interested by the possibility for the countries exporting commodities used for livestock feed in the EU to supply EU approved GM material. One consideration of the possible risk of the commingling of EU non-approved GM material is the degree of plantings of GMO crops in these countries (Table 1.4). The possibility of segregation of EU approved and non-approved GM material in these countries is discussed in Chapter 3. Table 1.4, nevertheless, shows that GM crop production is developing rapidly, and has already become a considerable proportion of the plantings of some of the principal crops used for livestock feed. One qualification is the extent of crop production in a particular commodity with regard to the world production (and thus the possibility to make use of other suppliers): with regard to rapeseed production in the USA, the percentage of planting in this country is less than 1% of global production (GMO Compass, 29.11.2010).

Table 1.4: Plantings of GMOs in major countries as % of total acreage

	2002	2003	2004	2005	2006	2007	2008	2009
USA								
-Soybeans	74	80	85	87	90	92	92	91
-Maize	32	40	45	52	60	60	80	85
-Rapeseed	…	70	70	75	75	75	82	n.a.
Argentina								
-Soybeans	95	99	98	98	98	99.5	99	99
-Maize	30	35	40	60	65	65	83	85
Brazil								
-Soybeans	35	35	40	40	40-45	64	60	71
-Maize	n.a.	n.a	n.a	n.a.	n.a.	n.a.	85	85
Paraguay*								
-Soybeans	n.a.	69	60	n.a.	n.a.	93	n.a.	85
Serbia**								
-Maize								
Ukraine***								
-Soybeans								
-Maize								

Source: FEFAC (2007:5). Based on USDA; IAAS; Agriculture Canada (2008b). http://www.ers.usda.gov/Data/biotechcrops/ExtentofAdoptionTable1.htm, www.ISAAA.org (Clive James, 2009), www.gmo-compass.org

*Little is currently known about the current adoption rate of GM soy in Paraguay: a limitation is the availability and registration of reliable data. In 2003, a report to the US Congress (http://www.nationalaglawcenter.org/assets/crs/RS21558.pdf) mentioned that the use of pirated RR soybean seeds reportedly had spread to Paraguay. At that time, an estimated 69% of soybean area was planted to RR soybeans. [Food Chemical News, No. 12, Vol. 45, May 5, 2003, p. 17.] In 2007, SDA-FAS Foreign Agricultural Service published a GAIN-report (GAIN Report Number PA7002, 10/16/2007) that stated that about 90% of the country's total soybean crop were GM soy(for more details see country report).

**Currently Serbia does not produce any genetically modified crops for commercial use (Masclac, 2005), See also country report for more details

*** Officially there is not statistics on GM crops, since GM crops are not authorised in the Ukraine. According to other unofficial data, more than half the soybeans grown in Ukraine is genetically modified. This figure has risen from 45% in 2005 to 70% in 2009 (See country report for more details).

1.1.4 Review of previous investigations[6]

The European Commission published a report on the economic impact of unapproved GMOs on EU feed imports and livestock production (EC, 2007). The economic impact of a potential interruption of soybean/meal imports from the three major exporting countries (USA, Argentina and Brazil) was modelled. Three scenarios were distinguished depending on whether soybean/meal imports from one, two or all three countries are interrupted. The results suggested that if EU-non approved GM soybeans were cultivated only in the USA, but not in Argentina and Brazil, the impact on the EU market of an interruption of US supplies would be small due to the moderate US import volumes. However, if these GMOs were also cultivated in Argentina (medium impact scenario) or in Argentina and Brazil (worst case scenario), the estimated economic impact of a two-year import interruption would be severe, cutting EU feed supply (in soybean meal equivalent) by 3.3 million t and 25.7 million t respectively, with feed expenditure rising by 22.8% and by more than 600% respectively. The short-term impacts in the pig meat and poultry sectors would be a substantial reduction in production, exports and consumption, and a very significant increase in imports. For beef meat, production would be less affected, but exports would be significantly reduced (by 100% in the worst case scenario). Assuming that after two years (2009-2010) the import restrictions would be lifted again, there would be a more moderate but still significant medium-term impact beyond the period of the interruption. Given that EU livestock production accounts for about 40% of the total value of agricultural production a loss in competitiveness of the EU livestock sector, as indicated in the medium and worst case scenarios, would have important implications for agricultural incomes and employment, with considerable knock-on effects in the upstream and downstream industries, and significant increases in meat prices for the consumer. As a result of the import interruptions of soybeans/meal from the USA, Argentina and Brazil, animal production would expand in the overseas countries, as producers could take advantage of cheaper GM protein feed, while the EU would increase its imports of meat from animals fed with GM soybeans in these countries.

Backus et al. (2008) conducted a study to assess the economic consequences of asynchronous approvals for the EU livestock and food industry. The study was commissioned by the Dutch Ministry of Agriculture, Nature and Food Quality (LNV). The study of Backus et al. was based on desk research and expert interviews and was carried out as a ‘quick scan’ of the available information. The results showed how the policy of the EU has already led to difficulties with the import of raw materials from exporting countries where more GMOs have already been approved or are under development. The report argued that it is likely that in the near future problems will become more urgent. This could negatively affect the EU supply of raw materials and economic position of the European agricultural and food sector. The findings presented were dependent on underlying behavioural and technical assumptions and on the quality of the available information considered. The authors acknowledged that the need to simplify the analysis resulted in at least three important limitations. The authors did not assess the consequences of the possible redirection of investments by major food companies to non-EU countries on innovation. The possible consequences of shifting consumption patterns from poultry to beef meat were not analysed. Finally,

---

[6] The author of this section is Linus Franke.

valuation of the benefits associated with conventional production and consumption was outside the scope of this study.

A study by Aramyan et al. (2009) evaluated alternative tolerance thresholds for EU-unapproved GM soy in combination with alternative delay periods of EU approval for use in feed compared to approval for production in soy exporting countries. The study was commissioned by the Dutch branch organization for producers of animal feed. Different scenarios were analysed using a stochastic computer-based model of a three-segment supply chain of soy producers in the USA, Brazil and Argentina, EU importers and feed producers. The model was applied for the Netherlands. The time horizon was four years. The results suggested that in case of an introduction of a new GM variety in the US in a given production year, a one-year delay in EU approval for new varieties resulted in a sufficient supply of EU-tolerant soy to meet the EU soy demand of 33 million ton in 2008 for any threshold level from 0.0% to 100.0%. If production of a new variety of GM soy in Brazil closely followed EU approval for this variety, for all tolerance thresholds for unapproved GM soy, total potential supply of EU-tolerant soy exceeded EU soy demand of 33 million ton. A delay in EU approval for new varieties for one year only affected estimated GM soy prices marginally, with an increase in mean values of prices from €290.00 to €292.20 per ton. However, a delay for two or more years increased estimated soy prices to a very high level, which would not be feasible for the industry to support. At these price levels there would be no more EU demand for soy as a raw material for feed, and the EU livestock industry would face a severe loss of competitiveness.

A study by Promar International conducted for the UK Department for Environmental Food and Rural Affairs (DEFRA) investigated the threats to the supply of both GM and certified conventional (non-GM) feed ingredients arising from the slow EU approval process for GMOs (slow relative to the regulatory approval processes in some of the leading exporting countries of animal protein) and the operation of a zero-tolerance threshold for the adventitious presence of EU-unapproved GMOs in imported supplied enter the EU (DEFRA, 2009). The study drew on a combination of literature review and interviews with representatives in the feed supply chain. The study concluded that it is not possible to obtain supplies of feed ingredients that are completely free from the risk of finding the presence of EU unapproved GMOs from an exporting country in which an EU unapproved GMO is grown. In the short term, the risks could be reduced by switching supplies away from the GM producing countries that are using EU unapproved GMOs to other exporting countries. The implementation of strict segregation and identity preservation systems may contribute to reducing but not eliminating risks of LLP of EU-unapproved GMOs occurring, although this course of action would be only practical and economically viable for high value ingredients. Risks may also be reduced by switching away from the affected GM crop / derivative. However, this would only be practical where the use of the crop / derivative is limited.

The Institute for Prospective Technological Studies of the Joint Research Centre of the European Commission (JRC/IPTS) published a report in 2009 by Stein and Rodríguez-Cerezo on the global pipeline of new GM crops and implications for trade. Based on desk research and the findings of a workshop organized by IPTS, this report presented an overview of the current status of approvals of GMOs in different countries with relevance for EU trade. It also presented a database of GM crops that were in the pipeline and may be marketed worldwide in the short term (2-3 years from 2008) to medium term (7-8 years from 2008). The pipeline was compiled for the seven crops (soybeans, maize, rapeseed, cotton, sugar beet, potatoes and rice) for which GM varieties already existed or were likely to be marketed in the near future. The results predicted a significant global increase in the number of individual commercial GM events. Individual GM events can easily be combined by conventional crossings by plant breeders to generate new GMOs with multiple desirable traits. Such "stacking" of events was already common in maize and cotton. In countries where stacked GM crops are required to go through the regulatory system as a new GM crop, as is the case in the EU, the possibility of generating new GM crops by stacking individual events will create an increasingly large number of new "approvable" GMOs. This will cause significant increase in the workload of regulatory systems and will likely contribute to the asynchrony of approvals. Most of the existing events in commercial GM crops were developed by (private) technology providers from the USA or Europe, and cultivated first in North and South America. These developers also tended to seek broad authorisation of their products in key export target markets (in particular the EU and Japan). However, by 2015 about half of the events in commercial GM crops are expected to come from national technology providers in Asia and Latin America, designed for domestic agricultural markets. It seemed very improbable that all these new GM crops will be submitted for approval in the EU. Hence future incidents due to LLP in imports of crops or processed foods from these countries are likely.

For professionals in the global food and feed chain, participating in the workshop organised by JRC/IPTS, the economic risk of rejections of shipments at the EU border was the major problem in the context of LLP. Part of this problem, the "destination risk", arises if the tests for the detection of unauthorised GM material in imports are only carried out at the port of destination. Commodity traders also questioned the possibility to comply with a zero tolerance policy for LLP of unauthorized material. A possible consequence mentioned was that exporters could sell their grain to "preferred buyers", i.e. to countries that have found concerns about LLP not justified and to importers that are known to create little problems. As risk is increased if there is uncertainty whether imported grains will be in compliance with LLP regulations, prices are likely to rise.

A recent study by G. Philippidis (2010) uses a Global Trade Analysis Project (GTAP) computable general equilibrium model to examine the impact of trade disruptions caused by asynchronous GMO approvals on feedstuff prices. Several scenarios were examined involving the loss of one, two or three major exporters to the EU (Argentina, Brazil and USA). The impact from the loss of all three suppliers was estimated to be a 500% increase in feed costs within the EU market. Such feed costs increases were found to cause a 34% contraction in the EU poultry and pig production and smaller ones in cattle, sheep and milk production. Because of reductions in production and price increases Philippidis finds that EU exports of poultry and pig meats decline between 40% and 50% while meat imports from Brazil, the US and other countries increase and erode the competitiveness of the EU livestock industry.

1.2 Analytical framework

In order to structure the investigation into the implication of asynchronous GMO approvals for EU imports of animal feed, the study is organised by themes. These themes are related to the methodology, as described in a following section. The themes are not intended to be undertaken in a sequential manner, but rather as a way of providing focus to coherent groups of research activities. A brief overview of the five themes is given before discussing the supply chain approach taken for elaborating the analytical framework. The analytical framework, as has been worked out in this study, is a supply chain approach.

1.2.1 The five study themes

Theme 1 concerns the elaboration of a general analytical framework by which to take into account the economic effects of asynchronous authorisations. It establishes the causality between the impacts of asynchronous authorisations through the disruption in the delivery of imported livestock feedstuff, on the one hand, and the competitiveness of EU livestock production, on the other, because of the effects on feed price and quantity within the EU. The possibility to substitute feed ingredients for the part of livestock feedstuff no longer being imported is an element in the overall price effect affecting the livestock sector. The reaction of the livestock sector to the change in the availability of feedstuff, in price and in type, has repercussions on the operations of related up-stream and down-steam industries as well as upon consumer welfare, and thus these factors are also part of the framework.

Theme 2 is the analysis of the occurrence of GMOs and the supply of feedstuff by the main exporting countries. In addition to investigating the legislation and practice with regard to GMO authorisation in these countries, the research carried out establishes the level of GMO adoption in respect to the area planted with maize and soy. The history of legislation and its implementation, along with the progression of GM adoption over time for planting maize and soy, together allow scenarios to be made of GM maize and soy production in the short and long term time frames of this study (2012 and 2020, respectively). The estimation of future GM production also takes into account the probability that asynchronous GMO approval will occur, with the consequence of the disruption of feedstuff exports from these countries to the EU. The scenarios are used to establish the parameters for a bi-lateral trade analysis to understand their implications upon the maize and soy supply chains at the world level; it is thereby also possible to identify possible replacement sources for maize and soy worldwide.

Theme 3 addresses the availability of feed products and substitutes (namely for maize and soy). In the event of disruption in the supply of maize and soy based feedstuff, the possibility of their replacement from other sources or through substitution by other feed ingredients is of critical importance for maintaining the EU livestock sector and its competiveness in the domestic and world markets. This requires knowing what are the possible countries that could replace lost export sources of maize and soy as well as the types of alternative feed ingredients that would not only be available in the world market, but which would also satisfy the protein and energy requirements of the various animal components of the EU livestock sector

Theme 4 is the assessment of the implications of possible feed shortages. In the eventuality that replacement or substitution for maize or soy occurs, within a situation where their import is affected because of asynchronous GMO approval, the degree of the possible change in feed availability and price should be anticipated in order for the EU livestock sector to follow the most appropriate adaptation strategy. The assessment carried out provides a range of economically-driven impacts concerning the livestock sector, the related up-stream and down-stream economic activities and also consumer welfare. The assessment indicates the relative competitiveness of the sector under the different scenarios elaborated through the research for Theme 2.

Theme 5 is an investigation of the possibility to segregate EU unauthorised GMOs all along the supply chain, so that there may be the possibility for countries supplying the EU to continue exporting feedstuff composed of authorised GMO material while also planting unauthorised GMO crops. Table 1.1 shows the main world producers, exporters and importers for maize and soy. On this basis, this supply chain analysis undertaken in this study concentrates with regard to maize on the Argentina, Brazil, Serbia, Ukraine and the USA; and with regard to soy, the study concentrates on Argentina, Brazil, Paraguay, Ukraine and the USA.

1.2.2 The elaboration of a general analytical framework

The aim of this section is to present a general analytical framework by which to analyse the potential economic effects of asynchronous approvals of new GM events by the EU upon the EU livestock sector. The set-up of the study is guided by the structure of the soybean and maize, feed, livestock and animal products-supply chain and the identified relevant issues across it. Figure 1.1 provides a brief overview of the various stages of the supply chain. As this figure shows, the chain goes from primary production taking place at different locations in the world to the final consumer of livestock products in the EU, and all the sectors in-between. Among the issues in need for careful examination are the development of the GM crop events in the pipeline, the adoption of non-GM, EU approved GM and non-EU approved GM by farmers, the risk on commingling (within as well as between different crops or low level presence (LLP) issues), the possibility to segregate products in a sustainable way and at which price, the influence of seasonality on potential disruption of feedstuff supplies, and the possibilities to replace soybean and maize products by tradable agricultural commodities as well as by home produced tradable and non-tradable (e.g. grass, roughage) products.

The key issues are:
- The number of GM events of soy and maize that are in the pipeline.
- The approval of GM events in producing as well as importing countries and the asynchronicity in GMO approvals between different countries.
- The adoption of (new) approved and unapproved GM crops, and the final production of non-GM, EU-approved GM and non-EU approved GM crop events.
- The transportation, handling and trading, including the possibilities to preserve the identity of non-GM and EU approved GM crops (segregation).

- Related to the previous point, the issue of low level presence (LLP) or commingling of unauthorised plant material has to be accounted for (e.g. material not only coming from maize and soybean GM plant material, but also from other plant material, including those having their origin in experimental field trials or unapproved non-commercial events).
- The sourcing of the EU feed complex (consisting of the compound feed sector and on-farm feed mixing) with maize and soy feedstuffs, their role in feed composition (taking into account animal specific feed needs) as well as the ease with which they may be substituted for by the use of alternative feed ingredients in the case of supply disruptions.
- With regard to the impact of potential supply disruptions, not only the risk of such a disruption occurring matters, but also the place and time of occurrence need to be accounted for, since the growing seasons differ in different producing countries (e.g. northern and southern hemisphere). This issue is known as 'seasonality'.
- The impact of a potential supply disruption on the livestock sector and the final consumers of its products is the key issue. This includes the impacts on farm profitability and competitiveness as well as the impact on consumer expenditure, consumption level of livestock products and welfare.
- Therefore the possibility of substitution of other feedstuffs is of critical interest, for it is a solution that will be able to dampen or alleviate the negative effects of a supply disruption.

The analytical framework is discussed in more detail in Chapter 2. The basic factors of the GMO pipeline and the possibility of substitution of livestock feedstuffs are the underpinning of the analytical framework. Other aspects, however, are also involved, and among them are the Low Level Presence of EU unapproved material in imported livestock feedstuff, the importance of seasonality in the production of soybeans and the practical limits of the possibility to substitute for feedstuffs in terms of constraints related to re-organising trade patterns, which are also elaborated upon. The basic structure of the analytical framework is a supply chain approach, as presented in Figure 1.1.

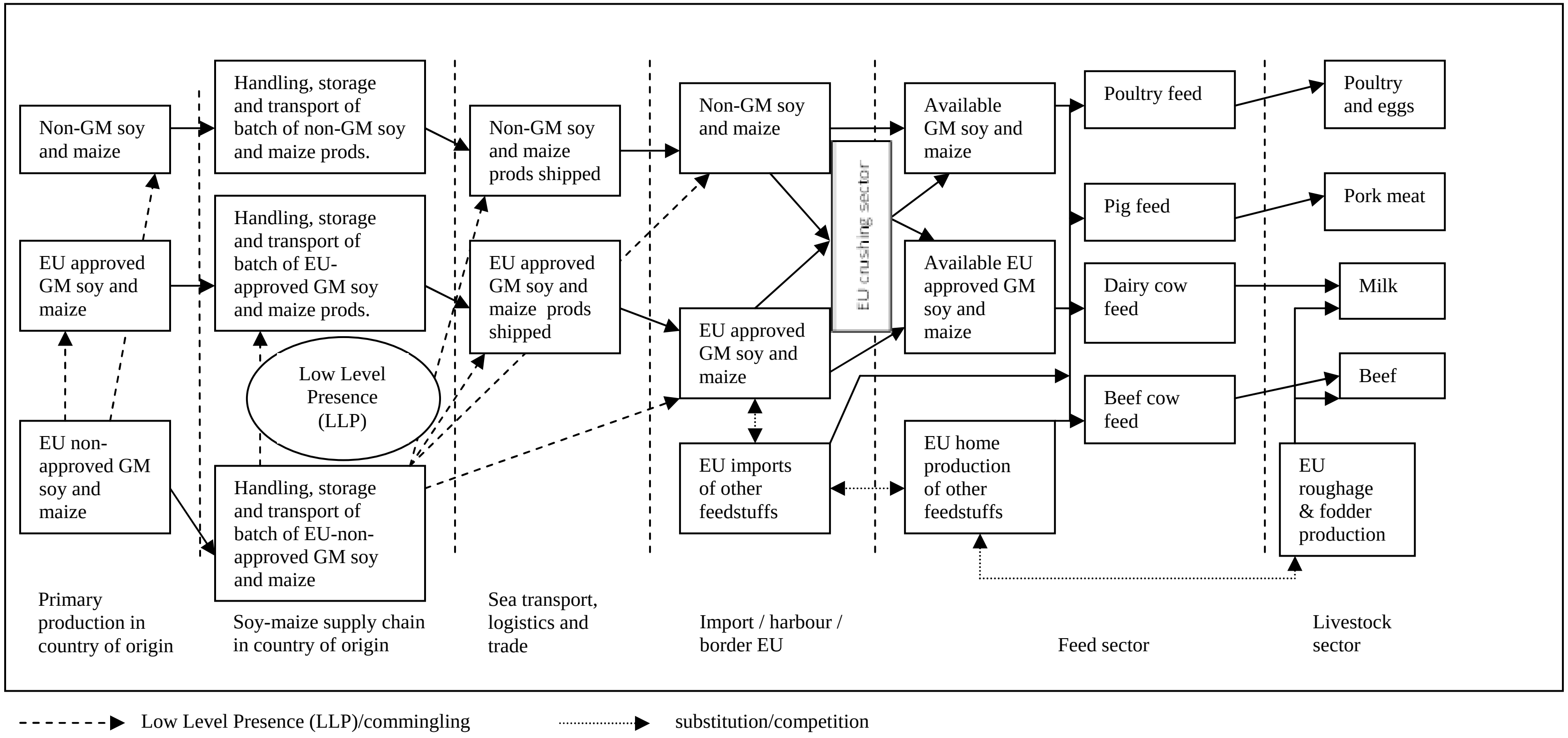

Figure 1.1: Soybean, maize, feed, livestock and animal products supply chain

1.3 Methodology

1.3.1 Overall framework for the implementation of the study

The methodology for the study is composed of four principal phases, and the overall framework is:

- Structuring the research
    - Literature review
        - Review of preceding studies on the possible impact of asynchronous GMO approvals upon the EU livestock sector
        - Research regarding the evolution of the GMO pipeline
    - Elaboration of a general analytical framework for assessing economic effects of supply disruption
    - Investigation into possibilities for substitution among livestock feed ingredients
- Observation and integration
    - Case studies of countries that are the principal suppliers of livestock feed material
        - Degree of adoption of GM events
        - Possibility of segregation within the supply chain
    - Investigation into the possibilities for replacement of trading partners in order to procure livestock feed material
    - Elaboration of scenarios regarding potential supply disruption
- Analysis of the economic implications of livestock feed supply disruption
    - Impact on livestock sector
    - Impact on related up-stream and down-stream sectors
    - Impact on consumer welfare
- Drawing conclusions and reporting

The relationship of the methodology is related to the analytical framework in the following manner.

- The structuring of the research phase involves the use of the output of Theme 1 (elaborating the general analytical framework) and Theme 3 (investigation into the possibilities of substitution among livestock feed ingredients). The literature review provides background information for both Theme 1 and Theme 2 (with regard to the elaboration of scenarios developing the circumstances for possible supply disruptions to be considered). The general analytical framework (Theme 1) guides the interpretation of the research outcomes achieved within this study.
- The observation and integration phase involves Theme 2 with regard to the research on the adoption of GM events: Theme 5 for the possibility of segregation within the supply chain, and Theme 2 for the integration of the preceding work for the elaboration of scenarios regarding supply disruption.
- The phase of analysis of the implications of livestock feed supply disruption (Theme 4) uses the material provided through the other Themes of the study.

- Finally, the last phase concerning conclusions discusses the outcomes of the study by Theme, and these outcomes are the basis for a general discussion of the implications of asynchronous GMO approvals for EU imports of animal feed products, in particular with regard to the EU livestock sector.

1.3.2 Overview of the qualitative and quantitative approaches

There are two sets of tools used for the research undertaken, reflecting a combined use of qualitative and quantitative approaches.

- Qualitative tools
  - Literature review
  - Case studies
  - Elaboration of the structure for the economic analysis
  - Elaboration of the scenarios of possible imported feed supply disruption
- Quantitative tools
  - Quantitative calculations based on economic logic, empirical fact finding and data assessment (these calculations are not derived from economic models).
  - Simulation of bi-lateral trade flows in the framework of the scenarios concerning trade disruption in imported feed supplies
  - Simulation of changes in livestock feed rations that would occur subject to changes in feedstuff price and availability in the event of a possible disruption in imported supplies, as characterised through the scenarios.
  - Simulation of the economic effects accruing to livestock feed ingredient shortages, specifically regarding the pursuit of EU livestock activities, the performance of related economic sectors and, as a consequence of the two preceding points, on the change in consumer welfare.

The qualitative tools are self-explanatory. Important additional information is that the case studies have been carried out for the major maize exporting countries[7] and for the major soybean and soymeal exporting countries[8].

The simulation models mentioned among the quantitative tools, on the other hand, are likely to be unfamiliar. They are introduced here so that the reader will be familiar with them when they are referred to in the presentation of the results of the study and how they were derived.

The simulation of bi-lateral trade flows is made in order to understand the general effects on the volumes and prices of livestock feedstuff imported into the EU in the event of a disruption in exports from one or more countries supplying the EU. For this a spatial equilibrium model is used, known as Takayama-Judge (T-J) in recognition of the original developers of this model. Based on values concerning production, storage, and freight costs, along with the tariffs applicable to export or import, the model resolves what would be the distribution of global trade for a particular commodity. In the case of this study, the T-J model has been used to analyse changes in trade flows

---

[7] Argentina, Brazil, Serbia, Ukraine and the USA.

[8] Argentina, Brazil, Paraguay, Ukraine and the USA.

for maize, soybeans and soymeal in the case of the cessation of export of feedstuff from one or more countries to the EU. The results obtained with this model are presented in Chapter 5.

The simulation of changes in livestock feeding rations following upon the alternative scenarios for the possible disruption of imported feedstuffs – summarized in Table 1.5 following, and fully developed in Chapter 6 – is made with a partial equilibrium model, known as CAPRI, and the outcomes of CAPRI, for one scenario, have been reviewed using a linear programming model, known as FeedMod, in order to have an assessment of the plausibility of the CAPRI outcomes. CAPRI stands for Common Agriculture Policy Regional Impact, and the model was developed at the University of Bonn. It is a ‘partial equilibrium’ model because it simulates the supply of only agricultural commodities within the EU-27 plus Norway, the Western Balkans and Turkey. It also simulates the functioning of world markets, but only for agricultural commodities. Achieving equilibrium means that after a change in one of the exogenous variables is introduced into the model, the model calculates new prices and quantities produced for agricultural commodities throughout all the regions covered by the model. Descriptions of the endogenous and exogenous variables, the agricultural products and the geographical coverage included in the model, as well as an explanation of its supply and trade modules is found in Britz (2005). FeedMod was developed by Tallage, and is a type of compound feed optimisation model that simulates how changes in prices of livestock feed ingredients will be reflected in the composition of feed produced commercially and on-farm. It takes into account the historical differences in feed composition by animal type and by Member State throughout the EU. A description of FeedMod found in Tallage (2010). Because the basic model for this simulation of livestock feeding rations, CAPRI, is used in an innovative way (extreme changes in maize and soy prices and availability because of disruptions in imported supply), the use of a second model (FeedMod) provides a comparison to the CAPRI outcomes as a way of controlling their plausibility; this control function is doubled by the use of expert opinion. The control of the CAPRI results for feed rations has been carried out for this study both by FeedMod and through the consultation of experts at Wageningen University. It should be noted that this comparative exercise is carried out for only one scenario of imported feedstuff supply disruption, which is the most severe in terms of the reduction in quantity.

The simulation of the economic effects of shortage in livestock feedstuffs, as would be brought about by a disruption of their import into the EU, is carried out by the use of the CAPRI model (the details of which are outlined above). CAPRI is used for several reasons: first, because of its capacity to spatially distribute the production of agricultural commodities in response to a change in an exogenous variable; second, because of its capacity to provide results by specific crop and by particular livestock animal type; third, because of its capacity to calculate feed rations on the basis of price changes for the ingredients used; and fourth, because of its capacity to provide information by which the impacts on related up-stream and down-stream economic activities as well as on consumer welfare can be estimated. The outcome of this simulation is found in Chapter 6. The capacity of CAPRI to correctly calculate feed rations, the third point, has been discussed in the preceding paragraph. The calculation of feed rations takes place as a preliminary step in providing results for prices and quantities of particular animal types.

1.4 Structure of the report

Having gone through the basic background for the study in the introduction, having considered the analytical framework, and having elaborated on how the methodology adopted gives support to the analytical framework, a brief discussion of the structure of the report follows.

The following chapters expose the results of the study in the following order:

- Chapter 2 describes the outcome of the primary research work carried out for Theme 1, the development of the general analytical framework, through the research on the degree of self-sufficiency of EU livestock feed production, the possibilities for substitution of livestock feed ingredients, and the evolution of the GMO pipeline.
- Chapter 3 addresses the issue of the capacity within the principal countries exporting livestock feedstuff to the EU to segregate EU unapproved and approved GM feed ingredients, specifically maize, soybeans and soymeal. This is Theme 5 of the study.
- Chapter 4 is the further elaboration of Theme 2 through the description of a set of scenarios on the possibilities for a disruption of feedstuff into the EU in the short-term (2012) and the long-term (2020), events which might be either short-run in nature, with an impact lasting between one and two years (incidents of Low Level Presence of unapproved GM material), or long-run in character, which would require 5 years or more for a new equilibrium state to be attained in for EU arable and livestock production (structural changes in the trade of feedstuff because of prolonged unavailability of EU approved GM material in the exporting country).
- Chapter 5 presents the results of the simulation of how trade in maize, soybeans and soymeal would change in the event of a disruption of exports to the EU from certain major suppliers. This is the elaboration of part of study Theme 2.
- Chapter 6 is the development of study Theme 4, the economic implications of possible feed shortages brought about because asynchronous GM approvals. This chapter presents results according to the scenarios elaborated in Chapter 4 that have an economic repercussion; one scenario presented in Chapter 4 has insignificant economic impact and is therefore treated in this chapter.
- Chapter 7 contains the conclusions of the study in terms of results, findings and conclusions, discussion of the main outcomes, recommendations and the innovations and limitations of this study.
- Chapter 8 is the bibliography.

Because the chapters of the study follow a certain logical order to prepare for the spatial trade analysis in Chapter 5 and the economic analysis made in Chapter 6, the information in Chapter 4 concerning the scenarios occurs posterior to the references to these scenarios in Chapter 3. The scenarios in Chapter 4 are in fact elaborated on the basis of the information that is established in the research work within Chapters 2 and

3. In order to allow the reader to have in mind the basic construction of the scenarios, a brief overview is presented in Table 1.5. Table 1.5 gives the name of each scenario, a brief summary of the type of supply disruption by duration and exporting country, and the commodities involved.

Table 1.5: Brief overview of the scenarios

Scenario	GREEN Supply shock in the short term (2012)	ORANGE Supply shock in the short term (2012)	BLUE Supply shock in the long term (2020)	RED Supply shock in the long term (2020)
Brief summary	Temporary loss of USA supplies during 3 months	Structural loss of USA, Brazilian and Argentinean supplies	Structural loss of USA supplies	Structural loss of most North and South American supplies, except Canada, for soy; structural loss of all the Americas and Western Balkans for maize
Type of livestock feed material involved				
Soybeans	X	X	X	X
Soymeal	X	X	X	X
Maize	*	X	*	X

* A disruption of import to the EU already exists because of asynchronous GMO approval

2 Effects of Asynchronous GMO Approval – General Analytical Framework

Roel Jongeneel, Linus Franke and Lusine Aramyan

2.1 The Problem

New genetically modified (GM) crops are being developed in major feed exporting countries at a high rate. The full segregation in these countries of authorized genetically modified organisms (GMOs) from those that are not in destination (e.g. the EU) is becoming an issue (as is presented in Chapter 3). International trade of agricultural commodities is compromised (as is presented in Chapter 5).

The regulatory procedures for the approval of (GMOs) in the EU differ significantly from those of exporting third countries. There are indeed significant discrepancies in the amount of time required to review and approve new GM crops between the EU and exporting countries. This fact can lead to “asynchronous authorisations”, where a GMO is fully approved for commercial use in food and feed in one of these countries, but not in the EU.

A major concern is the low level presence (LLP) of EU unauthorized GMOs in imported food and feedstuff. Food and feed consignments arriving to an EU harbour containing unauthorized GMOs – even at minuscule levels – have to be sent back, relocated, or destroyed. The EU legislation does not provide for any tolerance threshold for the adventitious or accidental presence of unauthorized GMOs even if they are approved elsewhere.

Thus exporters and importers face serious economic risks implying the possibility of trade frictions and shortages in feed supply. These can result in serious economic problems for the EU livestock sector.

Segregation becomes even more difficult over time as the number of GM events that are in the field or in the pipeline further increases. As a result the likelihood that trade disruptions get a permanent rather than a temporary character also increases. As such the provision of the EU livestock sector, which heavily relies on soybeans and soymeal as a feed protein source, is at stake. Trade disruptions in the soy and maize product markets might have serious impacts both in the short and long run on the viability and competitiveness of the EU livestock sector, as well as impact the welfare of EU consumers, which are used to consuming significant amounts of meat, eggs and dairy products in their diets.

Finally, the seasonality of production is a critical consideration, because the feedstuffs which are imported into the EU are coming from both the northern and southern hemispheres. Therefore a supply interruption occurring in one part of world may not be covered by supplies produced in another part simply because the growing seasons are different. The only solution is the possible substitution of feedstuffs.

2.2 GMO pipeline development

In 2009, Stein and Rodríguez-Cerezo produced a forecast of GM crops that will be developed in the years to come, the so-called GM crop pipeline. Below follows a summary of their findings. They used five different categories expressing the proximity of the respective GM "event" to the market. These categories are:

1. **Commercial crop**, commercialised GM events (those currently marketed in at least one country worldwide).
2. **Commercial pipeline**, GM events authorised in at least one country but not yet commercialised (commercialisation only depends on the decision by the developer).
3. **Regulatory pipeline**, GM events already in the regulatory process to be marketed in at least one country.
4. **Advanced R&D pipeline**, GM events not yet in the regulatory process but at late stages of development (large-scale multi-location field trials, generation of data for the authorisation dossier).
5. **Other crops**, GM events authorised in at least one country, but not commercialised or commercialised once but "phased out" commercially or legally afterwards.

Stein and Rodríguez-Cerezo only discuss new events that may be released and not possible combinations of events in stacked GM crops that may be released.

2.2.1 Soybeans

Between the time of data collection for the report of Stein and Rodríguez-Cerezo (2009) and now, some events have moved from the regulatory pipeline to the commercial pipeline or from the commercial pipeline to the "commercialized status". Commercialisation of Liberty Link soybean (A2704-12 and A5547-127) as well as Roundup Ready 2 soybean (MON89788) began in the USA in 2009 / 2010. Soy event CV127 moved in Brazil from the regulatory pipeline to the commercial pipeline in 2010.

Up to the present time, no stacked event of GM soybean has yet been commercialised. However, by 2015 there could be 17 new individual GM soybean events, which may be combined into a multitude of new stacked events. According to Stein and Rodríguez-Cerezo (2009), theoretically 136 new combinations of double stacked events are possible, although not all combinations would make agronomical or commercial sense.

2.2.2 Maize

For maize, there are already many commercial GM events available or in the commercial pipeline. Even more events are in the regulatory pipeline or in the R&D phase. There could be up to 24 individual GM maize events authorised for marketing by 2015. These events are then also available for combination into new stacked events, resulting in a large number of new possible GM maize lines.

2.2.3 Pipeline after 2015

Currently, the Stein and Rodríguez-Cerezo report (2009) contains the most thorough evaluation of the global GMO pipeline until 2015. They chose this short to medium term because it is impossible to assess which events in the initial phase of the R&D pipeline will eventually be released and commercialised, while there is a high level of certainty that crops in the advanced R&D pipeline or in the regulatory or commercial pipeline will be released in the next few years. However, there is also information from other sources available predicting the release of new events for the period after 2015, but because of the long time horizon the accuracy of such predictions is rather low. It is highly uncertain which events in the early stages of the R&D pipeline will eventually be commercialised.

In Figure 2.1 the pipeline of biotech soybean events until 2020 is presented as provided by the soybean industry (*inter alia* the American Soybean Association / ASA). Up to 2015, the pipeline in Figure 2.1 is similar to the pipeline described by Stein and Rodríguez-Cerezo (2009). After 2015, a number of new events with altered grain qualities are programmed to be released, although some properties are similar to those released before 2015 with only a different developer or owner of the event. The agronomic traits that may be released after 2015 include new herbicide tolerances (among others against the herbicide Dicamba). Moreover, some entirely new type of events leading to disease and pest resistances (*inter alia* against rust, aphids and nematodes) may be introduced. Moreover, GM soy with a higher yield potential may be released. The large international biotech companies (Monsanto, Pioneer, DuPont, Syngenta, BASF and Bayer) remain the main developers of new GM events, although some events are (co)developed by national research institutes.

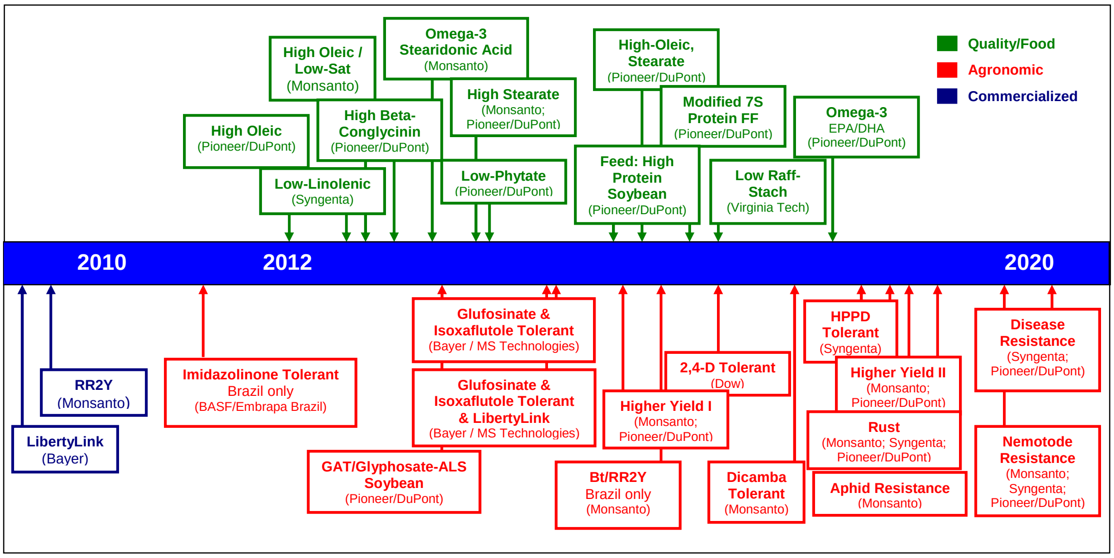

Figure 2.1: The pipeline of biotech soybean events and novel trait releases as derived from the soybean industry
Source: ASA, USSEC, USB. Updated January 2010

For maize, we consulted the websites of the different seed manufacturers. Monsanto mentions the different development phases on its website (Table 2.1), as does Pioneer Hi-Bred (Table 2.2). Genuity SmartStax is presented in Table 2.1, but in fact this is not a completely new event, but rather the result of stacking various already existing events. The 1st generation drought-tolerant maize will be the result of the cooperation between Monsanto and BASF (event name MON87460) and is also mentioned by Stein & Rodríguez-Cerezo (2009). The other events are in earlier research phases and were therefore not yet mentioned in their report. Concerning Pioneer Hi-Bred (Table 2.2), Stein & Rodríguez-Cerezo (2009) mention Optimum AcreMax1 (advanced R&D pipeline) and Optimum GAT (regulatory pipeline), but the other events in Table 2.2 are not mentioned in their report.

Table 2.1: The GM maize R&D pipeline of Monsanto (as per August 2010)

Phase	Product
Phase IV, pre-launch: average duration 12-36 months, success probability (liklihood of commercial release) 90%, 1 candidate, regulatory submission, seed bulk-up and pre-markteting	Genuity™ SmartStax™ Refuge-in-a-Bag (stacked herbicide tolerance and insect resistance events)
	1st Generation Drought-Tolerant Maize (drought tolerance)
Phase III, advanced development: average duration 12-24 months, success probability 75%, <5 candidates, trait integration, field testing and regulatory data generation	Roundup Hybridization System (RHS) for Maize (herbicide tolerance)
Phase II, early development: average duration 12-24 months, success probability 50%, >10 candidates, trait development, pre-regulatory data and large-scale transformation	Dicamba- & Glufosinate-Tolerant maize (herbicide tolerance)
	Corn Borer III (insect resistence)
	2nd Generation Drought-Tolerant Maize
	Higher Yield Maize
	Rootworm III (insect resistence)
Phase I, proof of concept: average duration 12-24 months, success probability 25%, thousands of candidates, gene optimization & crop transformation	FOPS Tolerance (herbicide tolerance)
	Nitrogen Utilization Maize
	Next-Generation Herbicide-Tolerant Maize

Source: Company website: *http://www.monsanto.com/products/Pages/research-development-pipeline.aspx*

Table 2.2: The GM maize R&D pipeline of Pioneer Hi-Bred (as per August 2010)

Phase	Product	Value
Phase IV, pre-launch: average duration 12-36 months, success probability (likelihood of commercial release) 90%, regulatory submission, seed bulk-up and pre-marketing	Drought tolerance I	Low
	Optimum AcreMax 1 (insect resistance)	Med
	Seed Production Technology	Med
Phase III, advanced development: average duration 12-24 months, success probability 75%, trait integration, field testing and regulatory data generation	Optimum AcreMax 2 (insect resistance)	Med
Phase II, early development: average duration 12-24 months, success probability 50%, trait development, pre-regulatory data and large-scale transformation	Drought tolerance II	Med
	Optimum GAT (herbicide tolerance)	Med
	Lepidopteran/Coleopteran Molecular Stack (insect resistance)	High
	Improved Feed & Processing Value II (consumer trait / processing trait)	Low
Phase I, proof of concept: average duration 12-24 months, success probability 25%, gene optimization & crop transformation	Nitrogen Use Efficiency	High
	Increased Yield	High
	Next generation lepidopteron resistance (insect resistance)	High
	Next generation coleopteran resistance (insect resistance)	Med
	Improved Feed & Processing Value III (consumer trait / processing trait)	High

Source: Pioneer company website: http://www.pioneer.com/home/site/about/research/pipeline
Value stands for the capture opportunity: Low < $100 mln, Med $100 mln-$400 mln, High > $400 mln.

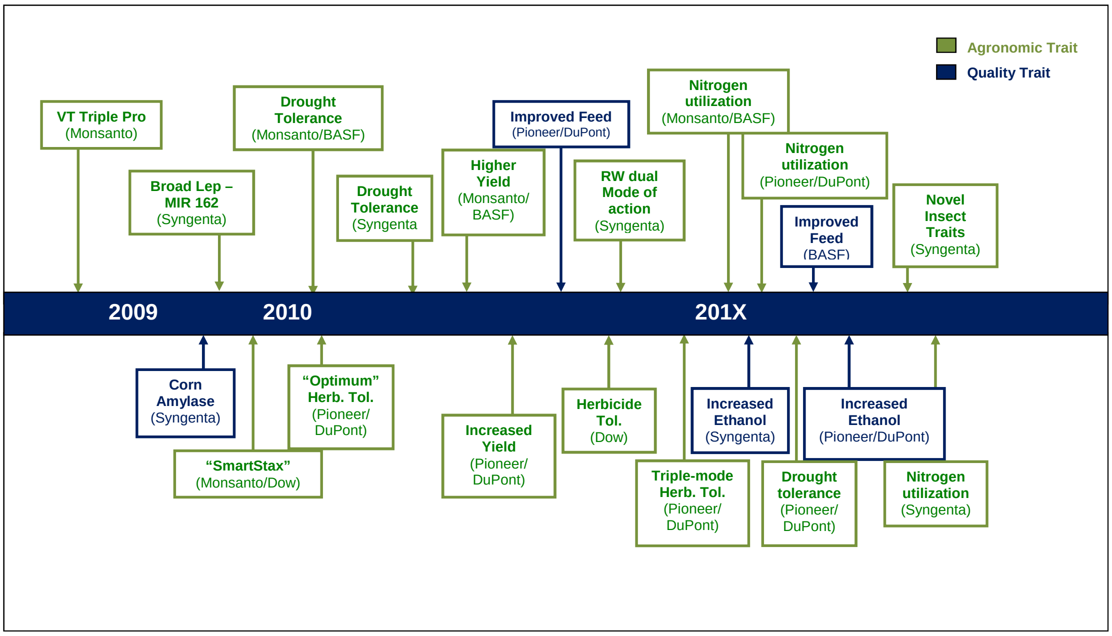

Figure 2.2: The pipeline of biotech maize events and novel trait releases as derived from the maize industry
Source: National Corn Growers Association: http://www.aceee.org/files/pdf/conferences/ag/2010/Tolman.pdf

2.3 Substitution possibilities for livestock feed

2.3.1 Introduction

In European agriculture livestock production plays an important role. The value of the livestock production in 2008 represents 40% (€152 billion) of the whole agricultural production in the EU (FEFAC, 2009). Animal feed, which includes compound feeds and feed material, represents the main input into livestock sector. Within the EU-27, about 468 mln t of feed are consumed by livestock each year (FEFAC, 2009). These feed materials mostly consist of roughages (228 mln t.) which are grown and used on the farm of origin. The rest (240 mln t) includes cereals grown and used on the farm of origin (51 mln t) and feed purchased by livestock producers to supplement their own feed resources. In the dairy sector, roughage is the main feed ingredient, while in other sectors, a large amount of compound feed is used (Burger et al., in preparation).

Compound feed is manufactured from a mixture of raw materials designed to achieve pre-determined performance objectives among animals (FEFAC, 2009; Tallage, 2010). The main ingredients for compound feed are cereals, with oilseeds meals (including soy) as a secondary, but significant, input (Burger et al., in preparation). This means that the compound feed industry requires a large amount of EU cereals, oilseeds and pulses. These raw materials come from different sources. Some raw materials are the co-products of the food industry. Other materials which cannot be grown in sufficient quantity in the EU are imported from third countries.

In theory a variety of ingredients can be used to produce compound feed for livestock. This creates room for substitution between ingredients. In this context, compound feed producers as well as farmers are continuously searching for feed compounds that meet nutritional requirements of animals at the lowest cost. Therefore, the price of the raw materials is closely related to animal nutritional requirements (i.e., energy and protein). At the same time, it should be considered that the availability of the possible substitutes constrains the substitution rates for different feed ingredients in practice.

Since the possibility for substitution between feed ingredients may significantly affect the economic assessments of the soy and maize markets, through changes in the relative prices of the ingredients used in the preparation of livestock feed on the import supply side, this section is devoted to this issue, and uses the output of the model developed by Tallage (FeedMod). In effect, substitution possibilities between feed ingredients have a significant influence on an economic assessment of the impact of a soybean or maize trade disturbance on the feed and livestock sectors. For this reason, this section illustrates rather extensively the substitution possibilities (i.e. alternative products and alternative origins) between feed ingredients while taking into account the physiological needs of livestock.

2.3.2 Identification of the substitution possibilities

2.3.2.1 Substitutes for Soy

One of the most important feedstuffs for the EU feed industry is soy. Soy is a high protein feedstuff, for which only limited alternative resources are available within the EU. As is discussed in Chapter 3, around 75% of soy used in the feed industry is imported, mostly from the USA, Argentina and Brazil; most of the rest comes from the European soy crushing industry importing most of its soybeans. The share of the imports from USA has declined and instead the share of Paraguay has increased. The combined EU import of soybeans and soymeal has grown since 1990s, and since 2000 it is around 34-35 mln t per year (see Table 1.1 in Chapter 1).

Table 2.3 presents the EU-27 balance sheet for protein rich feed materials for 2006/2007. According to data reported by FEFAC in 2008, the self-sufficiency of EU-27 in soymeal is only about 3%.

Table 2.3: EU-27 balance sheet for protein rich feed materials in 2006/2007 in '000 t

Commodities	EU production*		EU consumption**		Self Sufficiency
	Products	Protein	Products	Protein	
Soymeal	983	452	36,050	16,833	3%
Sunflower meal	3,386	1,016	4,975	1,493	68%
Rapeseed meal	9,191	3,317	9,825	3,439	94%
Cottonseed meal	476	193	258	105	184%
Palm meal	0	0	3,130	501	0%
Pulses	2,910	640	3,145	692	93%
Dried forage	3,828	727	3,600	684	106%
Corn gluten feed	2,311	485	3,189	670	72%
Miscellaneous	392	76	812	239	32%
Sub-total		6,806		24,401	28%
Fishmeal	443	306	800	552	55%
Total		**7,111**		**24,953**	**28%**

**EU production from EU seeds*
***Including consumption by the pet-food industry and on-farm use*
Source: FEFAC, 2008

Soybean production in the EU place mainly occurred in the following Member States during the period 2007-2009[9]. In Italy it has been between 50%-53% of total EU production (409-468 '000 t), followed by Romania at 10%-17% (85-130 '000 t), France at 9%-12% (63-109 '000 t), Hungary at 8%-10% (54-74 '000 t) and Austria at 6%-8% (52-71 '000 t). Some small quantities of soybeans are also produced in Slovakia and the Czech Republic.

Possible protein rich substitutes for soy in animal feed are rapeseed and rapeseed meal/cake, sunflower seed and sunflower meal/cake, palm kernel meal/cake,

---

[9] The source is EUROSTAT.

groundnut meal/cake, linseed and linseed meal/cake, wheat, cottonseed and cottonseed meal/cake, DDGS, peas, beans, lupine, alfalfa, clover, quinoa, duckweed, amaranth, potato proteins, and animal proteins (e.g. fish meal, meat and bone meal, milk proteins), according to information taken from multiple sources (Fiks-van Niekerk and Reuvekamp, 2009; Sikka, 2007; Froidmont and Bartiaux-Thill, 2004; Brand and van der Merwe, 1996; Kamp et al., 2008; Adeyemi and Familade, 2003; Christopher et al., 2007; Hasha, 2002; Landblom, et al., 2001; Adeyemi and Familade, 2003; ADAS, 2008). Rapeseed meal/cake, sunflower meal/cake and peas have been considered to be the most promising substitutes for soy in compound feed for pigs and poultry (Kamp et al., 2008; The Dutch Soy Coalition, 2009; ADAS, 2008), while beans and lupines for substitution in compound feed for dairy cattle (Kamp et al., 2008). However, prices of substitute products are related to the availability of these substitutes at the world market. The availability of a substitute at the world market determines whether a possible substitute can be used in reality.

Calculations made for this study provide the protein content and the global and EU production and trade of possible substitutes for soy in mln t raw product and in protein equivalents. The use of 32 mln t of soybean cake in animal feed is equivalent to around 15 mln t of protein material. This is more than 75% of the total protein in compound feed in 2006/2007 (see Table 2.4). If no soy can be imported in the EU, this amount of protein equivalents must be replaced by proteins from other sources. Next to the maximum content which can be included in the feed for specific animal types, the amount must be available on the world market. For the EU only the amount which is traded on the world but not yet imported in the EU can replace soybean proteins in feed. The last column of Table 2.3 provides this amount in mln t of proteins. Only wheat proteins are sufficiently available around the world. The first best alternative is protein from rapeseed, but this amount only covers 2.0 t of the 15 mln t of the required protein. Besides, one of the major rapeseed producing countries, Canada, produces mostly GM rapeseeds. According to GMO Compass (29.11.2010), GM rapeseed was grown on 6.2 million hectares in Canada in 2009, which is 95% of Canada's rapeseed crop. GM rapeseed is grown to a lesser extent in the USA (0.4 mln ha in 2007, according to the same source; ha in 2009 is not given) and in Australia (0.041 mln ha in 2009). Although many field trials with genetically modified rapeseed have been conducted in Europe, it is not yet being grown commercially (GMO Compass, 2008).

Proteins from sunflower seed and cottonseed are also possibilities with an available amount on the world market of 0.9 mln t and 0.5 mln t respectively. Cottonseeds are rich in protein, fibre and energy and most abundant plant protein feed available throughout the USA, after soymeal (NCPA, 2002) and it can be used in both ruminant and monogastric rations.

2.3.2.2 Substitutes for Maize

Maize imports into EU range 2.5-4 mln t per year (i.e. 4-7% of EU-27 production), according to the data in Table 1.1 (in Chapter 1). The main countries exporting to the EU are Argentina and Brazil. Some low and declining volumes come from USA, as is discussed in Chapter 3. During the last years the imports from Argentina and Brazil decreased. Instead imports from Serbia and Ukraine have increased.

In general Europe is quite self-sufficient when it comes to maize. About two-thirds of maize production in the EU is used in animal feed. The major maize producing countries in the EU are France, Italy, Romania and Hungary. Together these countries produce about 67% of the maize in the EU. To a lesser degree maize is also produced in Germany, Austria and Spain. GM maize is currently being grown in Spain, France, Germany, the Czech Republic, and Portugal (GMO Compass, 2010)

Potential alternatives of maize are wheat, barley, oat, paddy rice, rye, sorghum, triticale, millet, yams and maize by-products as maize gluten feed, maize gluten meal, and DDGS[10]. Production of maize in the EU of around 60 mln t exceeds the use in feed by around 50 mln t. Most maize used in feed is from EU production, so only a small part of the maize has to be substituted in case of a disruption in the trade of feedstuff supplies. The EU imports maize gluten (an energy rich maize feed from the USA) and sweet corn (from Argentina) in small quantities. Both of these countries are major producers of GM maize (GMO Compass, 2010).

The possible substitutes for maize including world and EU production and trade and usage in animal feed have been calculated. The result shows that sufficient wheat and barley are available on the world market for replacement of maize in animal feed. This does not consider nutritional constraints for inclusion of wheat and barley in animal feed for specific animal types.

2.3.3 Existing 'typical' feed ration by livestock type

The compound feed production in the EU is broadly split into the three main sub-groups of cattle/calves (25%), pigs (35%), and poultry (33%) of total production in 2008 (EUFETEC, 2008). Cereals are the main ingredients used in animal feed followed by cakes and meals. As it was shown in the previous section the feed ingredients can be substituted, however, to some extent. When substituting feed materials the prices of each ingredient relative to others play a major role in determining the feed composition. Whilst price tends to be the major factor influencing the choice of the ingredients in feed composition, factors such as digestibility and fibre content are also significant (Brooks, 2001). Fibre content is important, because it can be utilized for energy by ruminant animals (cattle and sheep), while pigs and chickens cannot digest fibre and may not tolerate high fibre ratios. This means that maize, for instance, tends to be a preferred feed cereal for pigs and poultry, because it is rich in highly digestible carbohydrates and is relative low in fibres, but contains a modest amount of proteins (Brooks, 2001; Hasha, 2002).

Nutrient requirements vary per animal, per stage of developments and other conditions. Feed composition also varies per country. For instance, in the Netherlands the level of cereals used in pork feed composition is relatively low compared to Germany or UK, instead the level of industrial by-products is high (Kool, et al., 2010). In the EU countries poultry feed generally has the highest content of protein, followed by dairy and pork feed (Hasha, 2002).

The existing literature provides a large variation in feed composition per animal type in different countries, since it depends on a large number of factors such as stage of

---

[10] DDGS = Distillers' Dried Grains with Solubles.

development of animals (e.g. age, weight), the productivity levels of animals, available raw materials per country (e.g. industrial by-products, availability of pasture, possibilities of import), production system (Bondt et al., 2009; Kool, et al., 2010; Brooks, 2001; Hasha, 2002; Kamp et al., 2008; Khalifa,1994). For instance, according to expert[11] opinion, a common diet for highly productive dairy cows in the Netherlands consists of 60 % roughages and 40% feed concentrates, where the roughages consist of 60% from grass and pasture and 40% silage. For dairy cows with low productivity, the common diet consists of 90% of roughages and 10% feed concentrates (mostly minerals and protein supplements). For dry cows, a diet commonly consists of 90% roughages and 10% feed concentrates (mostly minerals and protein supplements), where roughages consist of 1/3 from grass and/or pasture, 1/3 from silages and 1/3 from straw (to compress/decrease feed intake and to avoid fatting).

Based on the literature study and expert judgment it can be concluded that it is rather difficult to set a typical diet per livestock for the entire EU. Even between northern European countries with rather similar production systems and climatic conditions, there are differences in feed composition per animal type. To give an idea about differences in the feed diet, Table 2.6 presents a typical diet for fattening pigs for the Netherlands, UK, Germany and Denmark (this table contains the only comparative data that is available in the literature with regard to feed composition and feeding value per livestock type).

---

[11] Experts interviewed for this study are scientific researchers at Wageningen UR Livestock Research

Table 2.4: Feed composition and feeding value for fattening pigs in Netherlands, UK, Germany and Denmark

Feed Ingredient proportions	Netherlands (%)	UK (%)	Germany (%)	Denmark (%)
Wheat	20	30	30	20
Barley	20	15	30	30
Rye		5	5	5
Triticale		5	5	5
Oats				
Tapioca	10			
Wheat middlings	10			
Maize gluten feed	2.5			
Bread meal	5			
Soymeal	12.5	14	10	14
Soybean expeller				
Rapeseed meal	7.5	7.5	12.5	7.5
Palm kernel	2.5	1	1	1
Soybean oil	1.5	2	2	2
Molasses	4	4	3	4
Sugar beet pulp	1			
Sunflower seed expeller				
Peas				
Fish meal				
Gross Energy (GE) (MJ)	16.6	16.2	16.3	16.2
Digestible energy (% from GE)	79.9	82.6	81.7	82.6
EW	1.08	1.08	1.08	1.08
N-content	25.3	26.1	25.8	26.1

Source: Kool et al., 2001

Several studies have been conducted to analyse the maximum possible rates of substitutes for soy and maize in compound feed for different species. The substitution of one feed ingredient with another may affect the output levels of livestock production (e.g. milk yield, body weight), such as in the work of Khalifa, et al. (1994), Landblom et al. (2001), De Boer, et al. (2006), Sikka (2007), Kamp et al. (2008), Adeyemi and Familade (2003) Christopher et al. (2007), and Froidmont and Bartiaux-Thill (2004). Some studies have shown that if soy in compound feed was totally replaced by lupine, standard milk production of high producing dairy cows would not change, but milk fat percentage would be reduced (Froidmont and Bartiaux-Thill, 2004). Other studies show that substitution of soymeal with sorghum gluten feed reduced the rate of egg laying and feed intake and increased the feed conversion ratio. Thus it was concluded that sorghum gluten feed protein is not equivalent to soymeal protein, but it can replace 50% of the soymeal protein in the diets of laying hens on an economic basis (Khalifa, et al., 1994). Peas have been considered to be promising substitutes for soy (up to 50%) in compound feed for pigs and poultry while field beans/lupines for substitution in compound feed for dairy cattle, however only if market prices are favourable. In order to obtain a better insight into the substitution possibilities for soy and maize, several experts have been asked to give their judgment on this matter.

According to expert opinion, the maximum rate of substitution of soy for the cattle could reach up to 100%. The same percentage holds for the maize. The maximum rate of the use of grass in feed for grazing cattle is 100%, while for beef cattle in the barn this is very limited. For dairy cows the roughages in feed intake consist of 100% grass (or silage-grass). In the diet of fattening pigs from half to two thirds of the soymeal can be substituted by other ingredients. In the case of maize substitution, expert opinion is that all the maize can be substituted by other ingredients. For instance in the Netherlands many diets for fattening pigs contain no maize. In the diet of poultry meat soy can be substituted by 60% and maize by 100%.

2.4 Issues concerning the trade of feedstuff supplies

2.4.1 Seasonality in production of livestock feedstuffs

As regards the responsiveness of supply to price signals or trade disruptions, several factors play a role. In the short run the possibilities to adjust are in general less than in the longer run. Inflexibilities in the short run can be due to time lags in production (e.g. between planting decisions and harvesting), time lags in trade (long distance transportation), and logistical issues such as forward contracting. All these elements in principle play a role in the soy and maize supply chains. An additional factor to be considered is that the growing seasons of the different suppliers are different. This in principle has implications for the possibilities for different suppliers to react in the short run on a supply disruption shock, which in essence depends on the moment within a year a shock occurs. When a shock happens to one country, while the other one is ‘out of season’ it cannot contribute counterbalancing the shock. This issue has received further consideration, in particular for soy, because of the relative importance of EU dependence on soy imports as compared to maize imports.

The main suppliers to the EU of soybeans are the USA and Brazil, and Argentina is the main supplier of soymeal. Brazil’s soybean production competes with the USA (northern hemisphere) and is concentrated in two main regions: South (historical centre of production including states of Parana, Santa Catarina and Rio Grande do Sul) and Center-West (including states of Mato Grosso, Mato Grosso do Sul, Paranagua and Rio Grande). Of these regions the South is semi-tropical and Center-West is tropical. In Argentina, most soybeans are cultivated in the Pampean region, which also has a semi-tropical climate, while cultivation in the warmer northern parts (e.g. the Chaco) has expanded in recent years. In general, soy crop production in Brazil and Argentina is about six months later than in the USA (Flaskerud, 2003).

As North America (harvest season October and November) and South America (harvest season March and April) have opposing growing seasons, their supply to the world market shows a different seasonal pattern. In general USA soybean stocks reach their highest level in November and then due to consumption and exports decrease to their lowest level in the month of August and September (and sometimes October). In contrast, for Brazil soybean stocks normally reach their highest stock level in April. Then due to consumption and exports their stocks over time gradually decline and reach their lowest levels in January and February. As a result, USA exports generally peak in the period November until April-May, whereas South America’s exports peak in the period June to November. Song et al. (2007, 21) argue that it is the seasonal production pattern which gives either South America or North America a dominant position to the Chinese market.

Among the five main exporting nations (Brazil, Canada, Paraguay, Argentina and the USA), Brazil still has substantial production of non-GM soybean and is also capable of separately handling GM and non-GM soybean. Brazil is currently the main source of GM and non-GM soybeans to the EU (see Figure 2.3). As the production of soybean in Brazil is seasonal, the supply of soybeans to the EU (be it non-GM and/or EU approved GM soybeans) could be seasonal as well. The possibility of seasonality in supply could be examined with an emphasis on possible temporary shortages. Seasonality *in demand* in the EU should also be taken into account. For this reason a preliminary analysis has been made about the EU imports on a monthly basis for the years 2007 up to and including 2009 (see Figure 2.4).

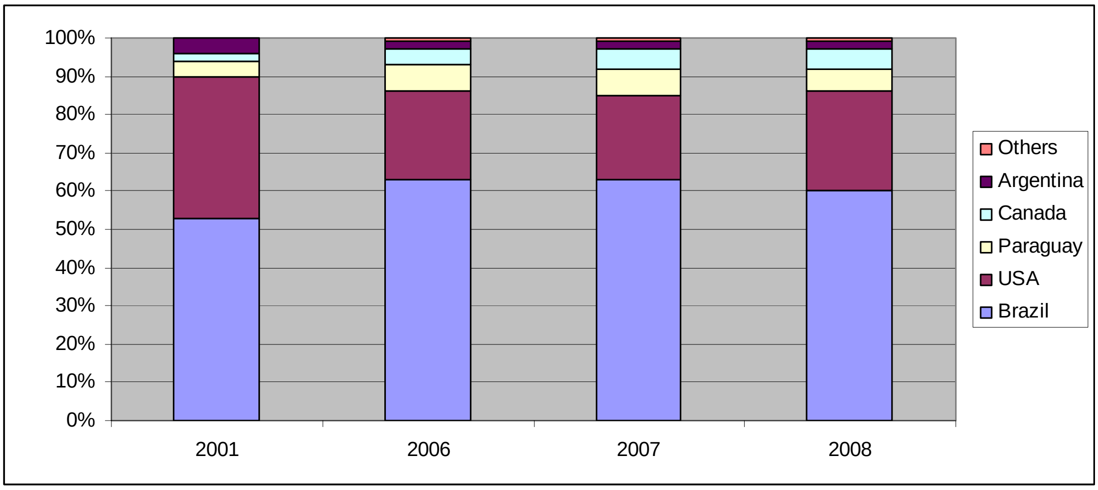

Figure 2.3: Evolution of main soybean supplier shares to EU market, 2001 to 2008, in %

The average EU-27 annual imports of soybeans for the period 2007-01 until 2009-11 were 11.1 million tons. As Figure 2.4 shows, the EU import demand for soybeans has a relatively stable pattern over the year, although fluctuations are also observed. The latter may be ascribable to variation in stockholding, weather conditions affecting supply, purchasing dates, etc. In case of perfect smoothing of demand over a year, one would expect a monthly import share of 0.083 of annual demand. There is some indication that the monthly import shares of annual demand are relatively low in those months where USA exports to the EU are peaking (November until March). Throughout the year, nevertheless, Brazil is the dominant supplier of soybeans to the EU. As a first hypothesis, therefore, the EU is likely to be more sensitive for trade disruptions affecting Brazil then to those affecting the USA. Moreover, the fact of year round imports from Brazil, while its primary production of soybeans is also known to have a seasonal patterns, gives support to the idea that stockholding in the producing countries contributes to smoothing supply over time.

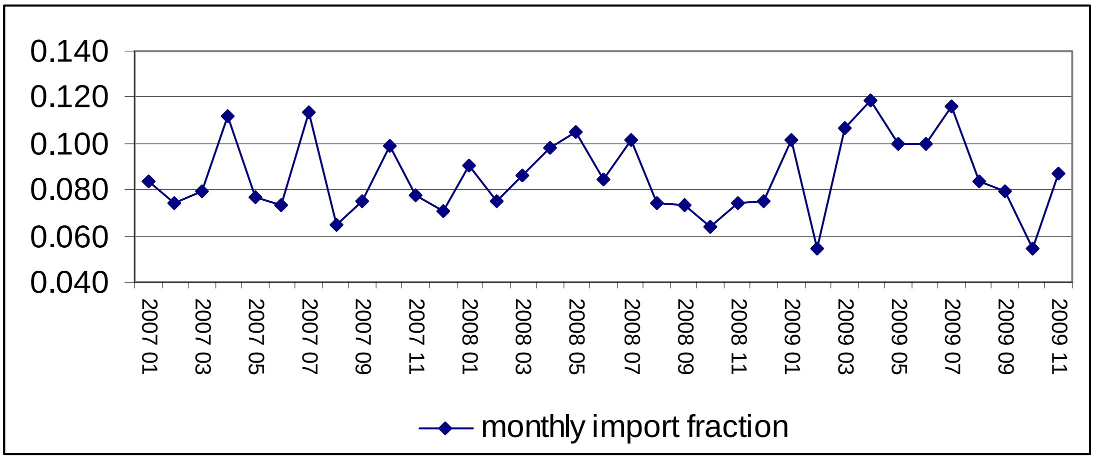

Figure 2.4: **Monthly share of annual soybean imports into the EU (period 2007-01 to 2009-11)**
Source: Eurostat (COMEXT).

As Figure 2.5 shows that there is a seasonal pattern in EU soybean imports, reflecting the seasonality in production in North and Southern Americas as indicated above. The average share of the USA in the EU's total monthly soybean demand in the period considered is about 20%, with a coefficient of variation (standard deviation/mean) of about 1.

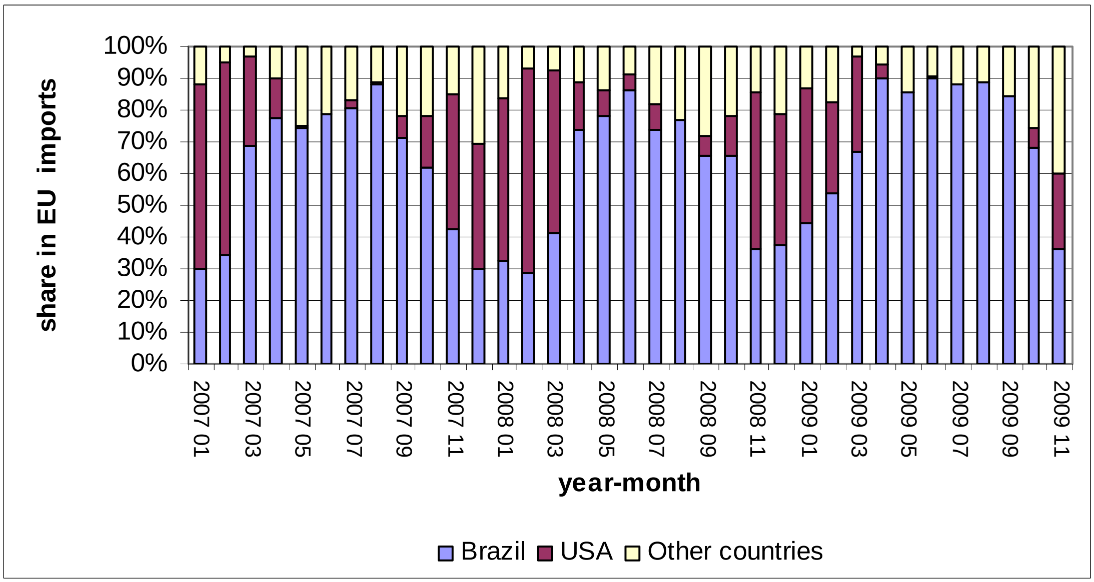

Figure 2.5: Seasonal pattern in EU-27 soybean (whether broken or not) imports in period 2007-01 and 2009-11: import shares from main exporting countries to the EU.
Source: Eurostat (COMEXT).

The EU-27 average annual import of soymeal (soybean cake) for the period 2007-01 until 2009-11 was 22.8 million tons. The comparison of this number with the soybean imports and applying a meal equivalence factor of 0.8 (as a convention) implies that the direct meal imports into the EU are about twice the amount of meal coming from (imported) beans crushed in the EU. EU meal imports come mainly from Latin

America, with the market share of the USA being limited. Just like with beans, the import of meal also shows a relatively stable pattern throughout the year.

From the first analysis it can be concluded that seasonality is potentially playing a role in the EU's soybean imports. However, as regards the EU's meal imports, which are about twice as important for the EU feed sector as the meal coming from crushed imported soybeans to the EU, seasonality seems to be at first sight much less an issue (on average more than 95% of EU meal imports come from Latin America). Based on available statistics and expert interviews, there is strong evidence that in the EU stocks of soymeal and soybeans (which can be crushed and then will release the meal for the EU market) have a pipeline character and are not sufficient to bridge delivery gaps. As is not uncommon in agriculture, also in the soy case, stocks are mainly held at the producing areas (e.g. USA and Brazil) and thus outside the EU. This implies that when a supply disruption occurs, in the very short run not much can be done to remedy this (e.g. transportation lag). Since in the short term substitution possibilities are limited and adjustment costs may be high, this is a reason to pay distinct attention to the potential short run impacts of a supply disruption, which might substantially differ from medium-run impacts. As regards maize, the situation is different, since the EU is both a producing and consuming area, and within the cereals complex substitutes are also available and stocks are kept within the EU. See Chapters 5 (in particular the GREEN scenario) and 6 (results and impacts) for further details.

2.4.2 Identity Preservation: mechanics and probability

The possibility to segregate production and the market channels for non-GM and EU-approved GM crops is the prerequisite for the continuity of the trade of maize and soybeans without interruption in the current context of asynchronicity and the presence of non-GM, EU-approved GM and EU-unapproved GM events in the global market. Thus there is a need to guarantee effective segregation and identity preservation (IP) throughout the market channel, from production to end use. The feasibility of segregation and the associated costs and risks may vary between countries, regions and farmers. At a regional and country scale, the availability of separate storage, processing and transport facilities for GM and non-GM products and between different GM events, among others, determines the feasibility and costs of segregation. The results of the possibilities for segregation follow from the in-depth analysis of exporting countries, the main conclusions of which are reported in Chapter 3 of this document.

2.4.3 Low level presence (LLP)

Identity preservation implies several actions including testing of seeds, cleaning of storage, inspection and cleaning of planting equipment, multiple units for product segregation, monitoring and inspection, testing, maintaining records of identity preservation, labelling, having documented IP protocols in place in handling, processing and trading facilities (Sundstrom et al., 2002). It should be noted that admixture of non-GM and EU-approved GM crops with EU-unapproved GM material, might also come from other supply chains (e.g. GM events of maize) or even from pilot trials and field samples of biotech crop developers (this is the so-called low level presence or LLP-issue). So, not only different stages of the supply chain have to be monitored and secured, but also the risk of admixture coming from other GM supply chains and the risks associated with (current or past) presence of biotech development operation (commercial as well as non-commercial) has to be considered. The magnitude of these costs, as well as the feasibility of IP, depends on the strictness of standards (i.e. zero tolerance being more difficult to achieve than higher tolerance levels), the shared use of infrastructure and logistic facilities, and overlap in production areas among different GM crops. See Chapters 3 and 4 for further details and estimated implications.

2.5 Impact analysis: market shares, competitiveness and trade

2.5.1 Structure of supply chain and possible changes

Understanding the potential impact of asynchronous approvals upon the EU livestock industry requires detailed economic analysis of the supply chain. This analysis, in turn, allows further development of the basis for understanding the risk factors and the sectoral consequences that asynchronous approvals of events could pose. The sectoral consequences are not limited to the livestock industry but also to the commodity merchandising industry, the oilseed crushing industry, the feed processing industry as well as the food industry that procures and sells related products (e.g. soybean oil, various food ingredients). Impacts are likely to also extend to crops that substitute or complement one another in the production of food, feed and fuel (e.g. maize and rapeseed). All these issues are part of a supply chain analysis, summarised beforehand in Figure 1.1 (in Chapter 1).

A further description of the supply chain in Table 2.5 elaborates on these matters by defining the analytical issues, and further relates these to tools for analysis, and their significance with respect to the occurrence and order of magnitude of trade disruptions because of detected unapproved GM material in EU imports.

Table 2.5: Livestock feed supply chain: stages, issues, tools and linkages to potential market disturbance

Stage	**Analytical issues**	**Tools for analysis**	**Linkages to potential market disturbance**
Innovations, GM events pipeline	Insight in (potential) characteristics of innovations. Insight into country specific regulatory reviews and approvals for cultivation and marketing. Role of asynchronous approval	Literature research, examination of regulatory review and approval procedures, Delphi-interviews among experts	Frequency and importance of asynchronous approval
Primary crop production	Adoption and diffusion of GM events	Analysis of past trends, costs and benefits of adoption of GM events and generating projections/best estimates for new events	Organisation of production, risks of commingling of products suitable for EU market
Marketing and handling	GM product segregation, feasible IP tolerance levels, segregation costs, the role and significance of carry-over stocks	Supply chain analysis, with particular attention to possibilities, costs and risks associated with identity preservation (considering commingled spill-over from various directions) meeting zero tolerance standards	Risks of commingling within supply segregation and different IP protocols, linked to standard stringency
Trade	Linking main supply and consumption regions, taking into account different standards	Spatial trade equilibrium model, including the world’s main production and consumption regions	Change in trade flows and prices of maize, soybeans and soybean products in the global and the EU market
Feed sector	Use of feed ingredients and possibilities of substituting one ingredient for another	CAPRI agricultural sector model, with disaggregated representation of feed sector at EU member state level; complementary study of compound feed composition with linear programming models	Adjustment of feed ingredient mix
Livestock sector	Sensitivity of livestock sector for feed price changes; determinants of livestock sector’s competitiveness	CAPRI agricultural sector model has differentiated livestock sector (poultry, pork, beef, dairy)	Economic impacts of trade disruption on costs and delivery and competitiveness of livestock products

2.5.2 Interaction of qualitative and quantitative analytical approaches and tools

As presented in Chapter 1 (in section 1.3.2), the methodology for the study is based on a combined qualitative and quantitative analysis. There is a pre-modelling stage which is characterised by qualitative analyses and the development of scenarios, and in the modelling stage a quantitative assessment using the two principal modelling tools (T-J trade model and CAPRI model) takes place, followed by a post-modelling stage of final preparation and interpretation of results (see Figure 2.6). Figure 2.6 provides a schematic overview of the qualitative and quantitative methods and tools that are used in various parts of the study, and how they are assumed to interact. The analysis consists of three stages.

Pre-modelling stage

It starts with a mainly qualitative pre-modelling analysis, in which issues like the GMO pipeline, authorisation procedures, adoption of GM crops, and LLP are analysed. In addition, and using the outcomes of the previous steps, the technical and economic possibilities of segregation (non-GM from GM and EU approved from EU-non-approved GM) are addressed. Based on the gathered information and analyses, a number of story lines are developed, which forms the basis for a limited number of scenarios. Whereas supply disruptions are at the centre of the scenarios, a refined analysis is required as to make a best estimate about the probability on having a supply disruption, as well as an analysis as to how the impacts of a supply disruption might differ depending on when (at what moment in time) and where (at which producing location) it takes place. Moreover, the issue whether shocks are likely to be incidental or will get a more structural character needs attention.

Modelling stage

The impacts of structural changes in world supply and demand as well as the response (in terms of changing trade flows, changing commodity prices and net exports to the EU from different locations) are assessed by the T-J trade model. Subsequently, the CAPRI model is used to further analyse the implications for the EU feed and livestock sectors, as well as for related industries, consumers, and the EU’s competitive position in livestock products. Because the feed sector and substitutability between various feed ingredients plays a key role in grasping the final consequences of shocks in soy or maize, this issue is further analysed (cross-check, wider and more refined analysis of potential role of alternative feed ingredients as considered in CAPRI) with the FeedMod (a model of the feed sector owned by the Commission). The modelling analysis contributes to assess the impacts in such a way that basic coherence and consistency is guaranteed. The outcomes in terms of predicted adjustments in the feed ingredient mix used in the EU are cross-checked and cross-validated with a qualitative analysis which relates the modelling results to best estimates of availability of alternative feed ingredients.

Post-modelling stage

The modelling stage has a follow up in the post-modelling stage, which consists of three main actions: (1) post modelling calculations aimed at determining impacts on related sectors and competitiveness; (2) interpretation and explanation of results; and (3) a further qualitative assessment of the results, in which elements that are considered to be highly relevant, but are beyond the scope of being captured by the models, are brought in and used to further qualify the quantitative findings.

Discussion

As Figure 2.6 illustrates, the analysis as foreseen in this study is complex and comprises many elements, which need careful examination and assessment. This implies intensive interaction between qualitative assessments methods and modelling assessments. Moreover, since there are a number of elements, which are difficult to being (fully) captured in existing models (and there are limits to the extent that models can be 'remade' within the scope of the study), the outcomes from the modelling exercises needs a careful post modelling interpretation and qualification step.

As regards the interaction between the models, the sequence is that the T-J trade model provides the impacts on world trade associated with structural changes taking place over time as well as those arising from (specific) supply disruptions. This includes the exports of soy products and maize from different regions to the EU. Since the T-J trade model considers only four products (three soy products and maize) and soybean and soymeal, and maize markets are treated as separate markets, the possibilities for substitution between products or feed ingredients it considers are limited. However, the strong point of this model is that it allows for a detailed assessment of the impact of supply disruptions on trade patterns. As a consequence of these properties, the T-J trade model can be argued to provide relatively short run impacts.

The CAPRI model, which is used for the assessment of the consequences of supply disruptions for the EU (availability of feedstuff and the impact upon livestock), allows for a wide range of substitution possibilities between feed ingredients (both tradable and non-tradable ones), including also a potential response in EU's home production. A discussion of the CAPRI baseline is found in Britz (2005)[12]. Relative to the T-J trade model, the CAPRI model can be argued to allow for a broader set of factors to adjust, and as such can be argued to provide medium to long run consequences of trade disruptions. The noted differences in the structure of the T-J trade model and the CAPRI partial equilibrium model are such that a one-to-one linkage of these models to each other is problematic, already from a conceptual point of view, let alone the practical problems it would generate. For that reason both models are used each for their own strength and treated as 'experts' which talk to each other and each bring in crucial insights. The FeedMod model is a supplementary model (as presented in section 1.3.2), and is used to cross-check the feed substitutability (and the related predicted feed ingredient mix used by the EU) as well as to to analyse the substitution in a more refined way (allows for further disaggregation of feed ingredients). Based on the outcomes of the FeedMod output and a qualitative assessment of the availability of substitutes (at a detailed feed ingredient level) in the market through expert opinion, outcomes of the CAPRI model are validated, or qualified.

---

[12] The CAPRI baseline follows the OECD-FAO outlook information, which is further disaggregate at EU MS and NUTS2 regional levels. Moreover the model takes into account existing trade and common agricultural policies (including already planned future adjustments such as the quota abolition in the dairy sector in 2015).

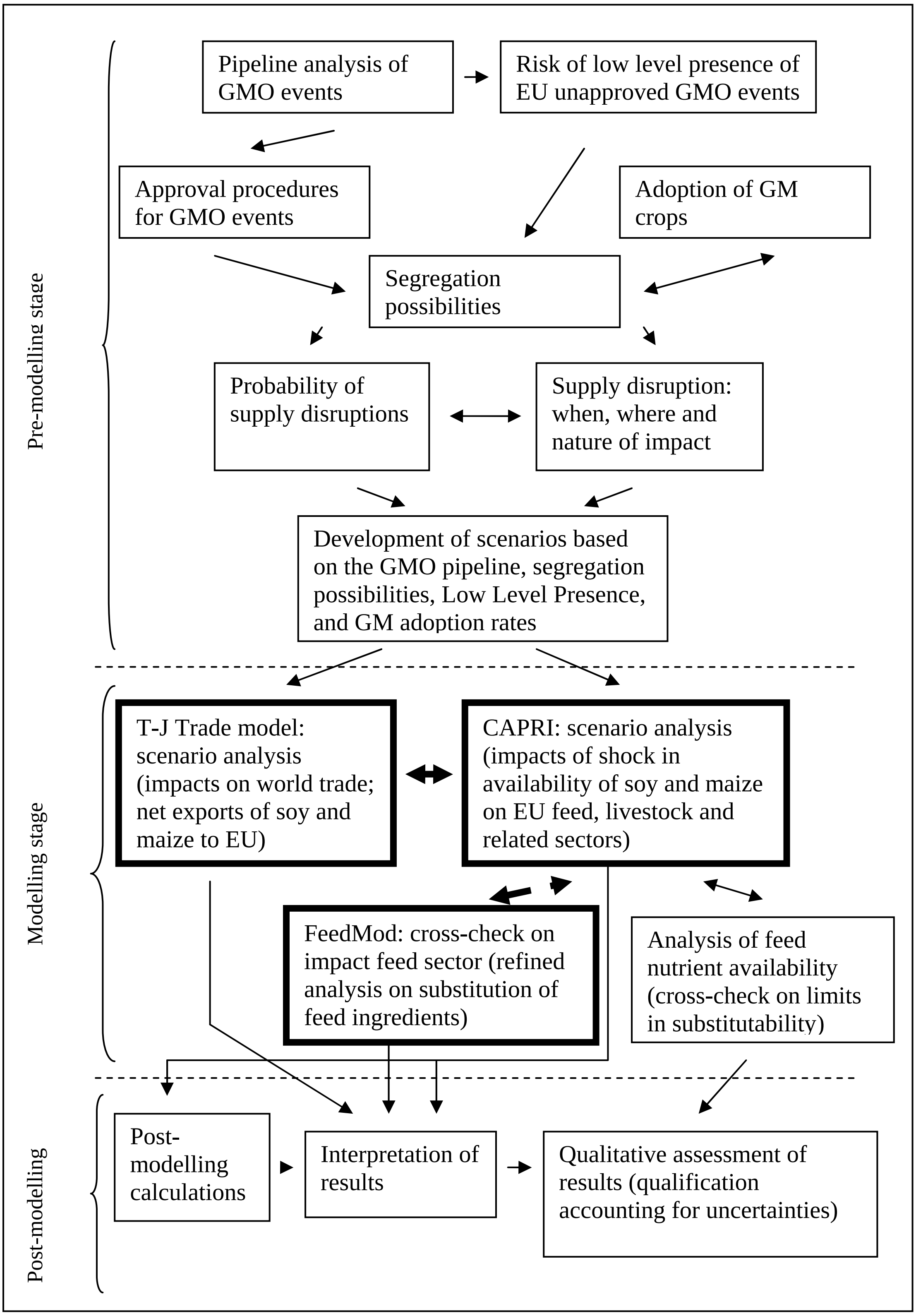

Figure 2.6: Interaction of qualitative and quantitative methods and models

2.5.3 Application of modelling tools to the scenarios

Changes in the export supply of EU-approved soybeans and maize (or its products) of key exporters can change not only the trade flows but also their available supply and price to the EU (Chapter 5). When a region starts producing EU-unapproved GM soybeans or maize or is partly disqualified as a supplier of identity preserved approved crops, a sequence of market responses is expected. Redistribution of trade could allow other exporters to supply the amount of EU-approved commodities forfeited by the disqualified supplier. In such a case, the total demand in the global market remains more or less unchanged and prices are expected to change only slightly to reflect increasing freight and other transaction costs resulting from less efficient trade routes in bilateral flows. The description of the scenario outcomes in Chapter 4 involves a detailed analysis of segregation possibilities for EU authorised and non-authorised EM events within exporting countries that is found in Chapter 3, and is the basis for the study of shifts in trade patterns and their consequences as presented in Chapter 5. If part or the whole of the forfeited exports cannot be made up by other exporters in the global market then an equivalent reduction in the total demand of the commodity would shift from the international commodity market to the IP market. This shift would tend to lead to a decrease in prices in the international commodity market and an increase in the prices of the EU-approved crop market through guaranteed IP. Over time, demand and supply shifts in these vertically differentiated markets are expected to lead to equilibrium where the observed price wedge is similar to the sum of IP costs and associated risk premiums. Short term market disturbances, uncertainty, transactions costs and other constraints on supply and demand adjustments can keep markets from reaching such medium to long term equilibriums for quite some time. In this context, the structure and price responsiveness of demand and supply in both the commodity and the through IP guaranteed EU-approved maize and soybean market in various regions are of great importance.

The use of quantitative models provides a detailed analysis of shifts in trade patterns and their consequences. The possibility of new entrants is taken into account. It is in particular the Takayama-Judge international trade model that is used for this assessment. The results and impacts on the EU feed-livestock supply chain are captured by the CAPRI model. For each scenario it describes the impacts on feed markets (volumes as well as prices), and how these ultimately translate into changes in feed costs, which in turn affect the competitiveness of the livestock sector. The impact on the livestock sector’s competitiveness is measured by the impact on the costs of production, profitability and market-share of specific livestock sectors. Since CAPRI contains the whole arable-pasture-livestock complex, the model takes into account changes in land management and competition between subsectors in agriculture as well.

3 Segregation of unapproved biotech events: feasibility and potential costs

Nicholas Kalaitzandonakes and James Kaufman

3.1 The Problem

EU imports from countries that produce both EU non-authorised and EU authorised grains[13] are possible only when these two types of grain can be perfectly segregated. Given the EU's policy of zero tolerance for unapproved biotech events, presence of even traces of such events in grain lots imported to the EU would deem them illegal. We are therefore interested to know the extent to which segregation can be used in key exporting countries in order to supply the EU with non-regulated maize, soybeans and processed products (e.g. soymeal). We are also interested to know whether such segregation implies incremental risks or costs which could affect trade. To answer these questions we examine certain characteristics of the maize and soybean supply chains in key exporting countries in order to determine their capacity to consistently segregate non-authorised and authorised grain.

3.2 Introduction

Over the last fifty years the global production, use, and trade of maize and soybeans have grown fivefold or more. In the last two decades, there have also been significant structural changes in these two sectors. These include: the emergence of South America as a leading maize and soybean production centre; the emergence of China as the dominant importer of soybeans; the restructuring and relocation of the global soybean processing sector; the increasing use of maize and soybeans as feedstocks to an expanding biofuels sector; and the emergence of biotechnology as the primary platform for technical innovation in these two sectors. These changes have caused the fundamental realignment of the global maize and soybean supply chains as well as significant shifts in product flows across domestic and international markets. The realignments of the global maize and soybean supply chains have significant implications for their current and future capacity to segregate and trade seeds and processed products free of regulated biotech events.

3.3 The evolution of the global maize and soybean supply

Maize is grown on almost 11% of the world's arable land and it is a key crop for many countries. The United States is the global leader in the sector producing 40% of the world's maize crop (Figure 3.1). China continues to increase its share of global maize production but it is still a distant second to the USA growing roughly 20% of world production. The EU, Brazil, Argentina and Mexico have also increased their production and together account for another 20% of world production.

---

[13] EU-authorised grains can be conventional grains that have not been genetically modified, segregated and certified "non-GM" grains or genetically modified grains containing biotech events that have received regulatory approval in the EU. Authorised grains are therefore not subject to EU import restrictions.

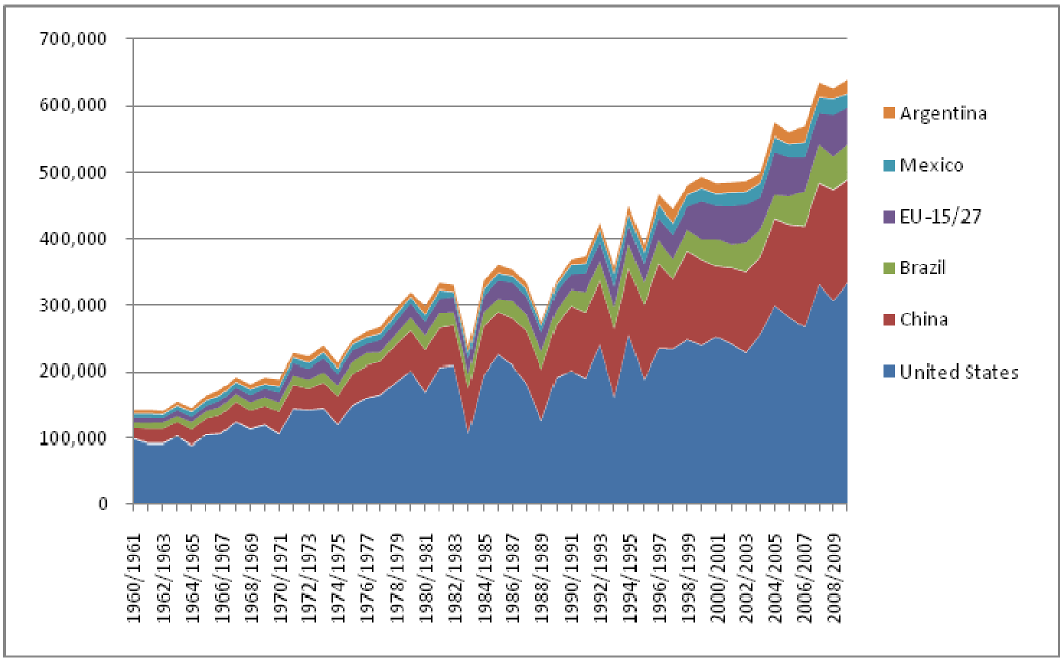

Figure 3.1: Maize production in key countries ('000 t)
Source: USDA FAS PS&D

Soybean production occupies close to 6% of the world's arable land and it is expanding faster than any other major crop. The USA continues to be the leading soybean producing country. At the peak of its dominance in the 1970s and 1980s it was producing 80% of the global total. Since the early 1990s, however, there has been a significant shift in the location of soybean production (Figure 3.2). Production in South America, led by Brazil and Argentina, has grown dramatically and has recently surpassed the United States' output. Today South America produces almost 49% of the world's soybeans with the USA producing just over 36%. Brazil has had the largest gains in share. The development of new soybean events tailored to its hot and humid growing conditions have helped to increase yields and have facilitated the opening up of new cropland. Brazil's production jumped from 20 mln t (19% global share) to 67 mln t (26% global share) between 1990 and 2010. Argentina has made similar progress. Unlike Brazil, much of its increase in production has been from increased yields and reallocation of cropland to soybean production. Argentinean production grew from 11.4 mln t (11% global share) to 54 mln t (21% global share) between 1990 and 2010. The fourth largest soybean producer is China, which has had relatively stable levels of production over time.

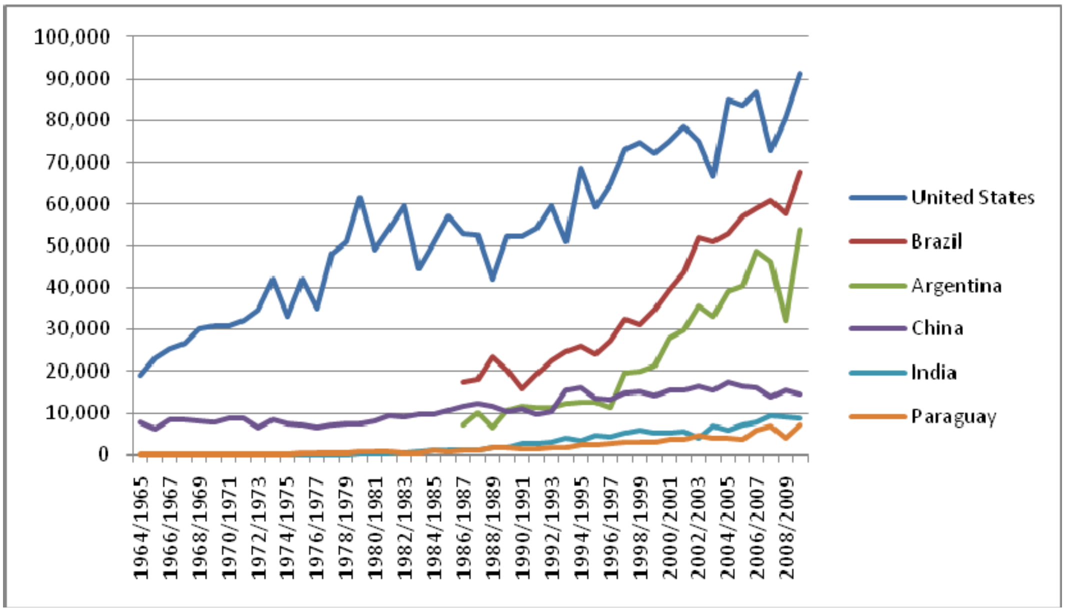

Figure 3.2: Soybean production in key countries ('000 t)
Source: USDA FAS PS&D

Growth in maize and soybean production has also translated into growth in trade. Production in the USA exceeds domestic consumption and allows a large exportable surplus to be traded in international markets. China and the EU are mostly self-sufficient and do not trade significant amounts of maize. Brazil consumes most of its production but it recently became a net exporter while Mexico recently became a net importer. Argentina does not have a large domestic maize demand and is thus it is a significant maize exporter. Since the 1980s, export growth has come from Argentina and some other smaller maize producers like South Africa and Eastern Europe as, well as from Brazil in recent years (Figure 3.3).

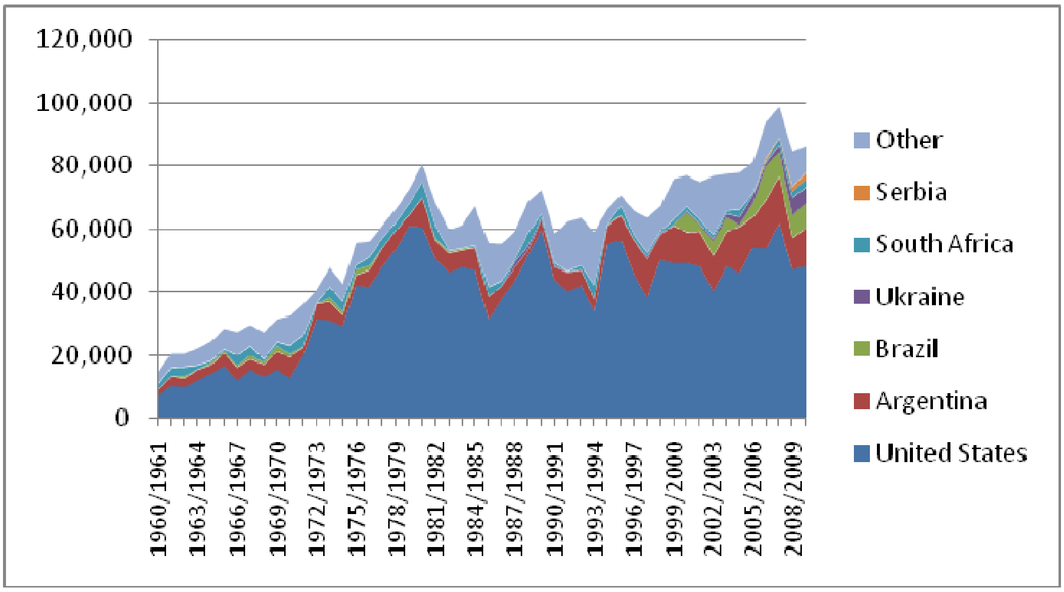

Figure 3.3: Maize exports of key countries ('000 t)
Source: USDA FAS PS&D

Growth in the trade of soybeans has been even more significant (Figure 3.4). Some producing countries export predominantly soybeans (e.g. the USA, Brazil, Paraguay) while others export mostly processed soybean products (e.g. Argentina). The United States is the largest exporter of soybeans (42% of total) followed closely by Brazil (34%). Argentina and Brazil are today's leading exporters of soymeal, together capturing 64% of world exports.

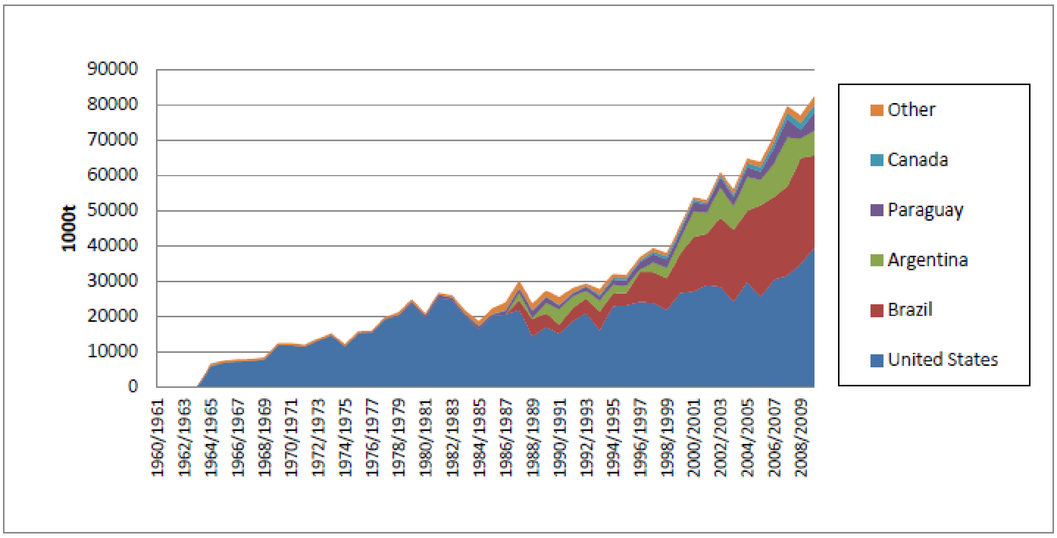

Figure 3.4: Soybean exports of key countries ('000 t)
Source: USDA FAS PS&D

All key maize and soybean exporting countries in the Americas and elsewhere in the world have adopted biotechnology (see Chapter 5). Indeed, in some occasions adoption has preceded regulatory approval (e.g. in Brazil, Paraguay and the Ukraine). Since a handful of countries (e.g. the USA, Argentina, Brazil, Paraguay, and the Ukraine) dominate global maize and soybean exports we can focus our attention on their capacity to segregate EU-unapproved events, without loss of generality.

3.4 Commodity and segregated maize and soybean supply chains

3.4.1 The maize and soybean supply chains

An expansive global network of interlinked firms and infrastructure used in the production, storage, processing and distribution of maize, soybeans and processed products has been built over decades. Every year, these supply chains must balance global supply and demand spatially (moving grains from surplus to deficit areas); temporally (storing grains when they are plenty and drawing from stocks when they are needed); and quality wise (moving grains of varying quality to their optimal uses).

Maize is consumed as food in most countries but an increasing share of global maize production is used as livestock feed, and more recently, as fuel feedstock. During harvest, maize is stored on the farm or in commercial storage (local/regional elevators). Maize stocks are then gradually sold to livestock producers, exporters, dry mills, wet mills, feed mills, and other maize processors (e.g. masa, lysine, bioplastics, etc.) over the course of the marketing year.

Wet mills account for the largest share of maize processing, producing sweeteners, ethanol and starch as primary products and maize oil and feed as co-products. The feed products include gluten meal, gluten feed, maize germ meal, and condensed fermented maize extractives (steepwater) all of which commonly end up in compound feed. Dry mills convert maize into 36% ethanol and 32% distiller dried grains with solubles (DDGS). DDGS are fed predominantly to ruminants as ingredients in compound feed and to local livestock in a wet perishable form.

Feed mills and livestock producers receive the largest share of the maize crop as well as maize processing by-products. Feed mills produce compound feeds which, in turn, are distributed to local/regional livestock producers. Maize intended for the export market is typically transported from local storage to terminal elevators where it is aggregated into large lots for transfer to distant ports or train depots.

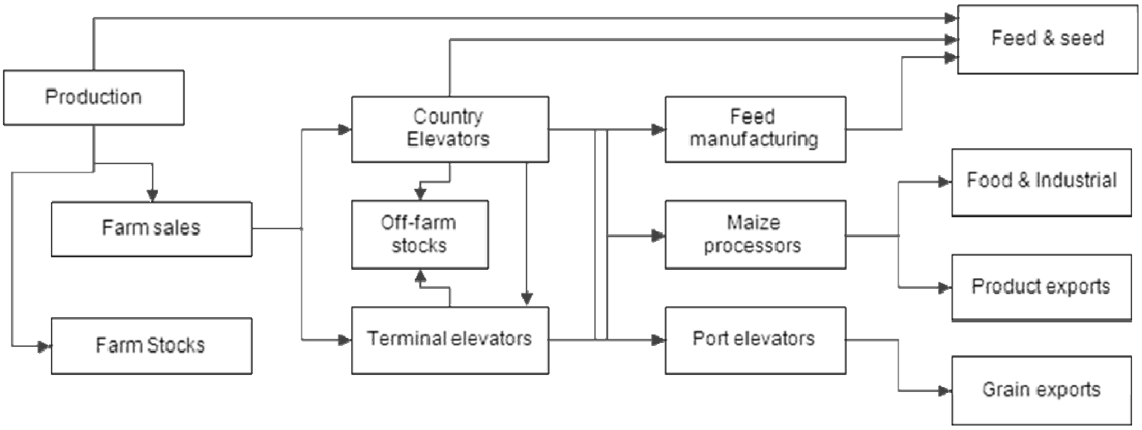

Figure 3.5: The supply chain of maize

Only 2-4% of soybean protein is consumed directly by humans in the form of soy food products (e.g. tofu, soy milk analogues) while the majority is used in the manufacturing of compound livestock feed and small amounts of fuel and industrial products. Soy processors crack, dehull, condition and flake the soybeans and then treat them with hexane to release the oil. The result is crude soybean oil (20% weight), soybean flakes, and hulls (80% weight). The crude soybean oil is then degummed and refined yielding gums (e.g. lecithin) and refined oil. The de-oiled soybean flakes can be turned into soy protein concentrates and isolates, soy flour, or, most commonly, soymeal with 48% protein content. The hulls may also be added back to the meal to yield a 44% protein content.

Soymeal is generally distributed to feed mills for use into compound feeds, export elevators, and animal feeding operations. Feed mills handle a large share of the soymeal and many tend to be regional, distributing mixed feeds to local livestock producers. As with maize, soybeans destined for export are sold by the local/regional elevators to large terminal elevators. The supply chain that facilitates all these value adding activities in the soybean complex is therefore similar to that of maize.

3.4.2 Commodity chains

Maize and soybean supply chains contend with many uncertainties that complicate their operations. The volatility of local production and demand from one year to another leads to significant shifts in the use of physical assets (e.g. storage silos, transport, processing plants) thereby raising the investment risk for such assets. Price risks are also significant. As they are traded, grains and products change hands many times in any given year, and in every transaction the buyer assumes price risk. Uncertainties in freight prices, interest rates, and in exchange rates of international currencies further add to the overall risk.

Complex institutions have developed over time to facilitate information flows between buyers and sellers and minimize risks in the maize and soybean supply chains. Futures markets have developed to diversify price risks. Buyers and sellers of grain can trade promises of future commodity deliveries in futures markets. Through hedging – making equal and opposite transactions on the cash and futures markets – farmers, elevator managers, traders, processors and others can protect themselves against adverse price movements while they hold grain inventories. Freight and exchange rate risks can be similarly hedged, at some cost.

Because maize and soybeans are bulky and relatively expensive to transport and store while their final unit value is relatively low, supply chains must also control operational costs in order to expand demand, supply and trade. To facilitate the exchange between buyers and sellers in distant markets while limiting operational and transactions costs, grades and standards have been developed for maize and soybeans. Grades and minimum standards enable buyers to determine grain storability, end-product yield, and quality without visual inspection. Public and private agencies provide inspection services and ensure that minimum standards are upheld.

Through the use of minimum standards a large number of transactions across the globe can be consummated. At the same time, grains with quality exceeding minimum standards are not rewarded within this commodity system, leaving price as the single means of competition. In this context, the dominant strategies for commodity producers and traders are cost and risk minimization.

Minimizing costs in every part of the maize and soybean supply chains is critically dependent on aggregation. Maize or soybeans from numerous farms and storage facilities are mixed throughout the supply chain, over time resulting in perfectly fungible and divisible product streams. This fungibility facilitates the efficient use of discrete storage, transport and processing assets and yields significant scale economies.

3.4.3 Rate of grain dispersion across the supply chain and Low Level Presence

Since aggregation and commingling of grains from various farms and storage facilities in different regions is on-going, grain dispersion of various origins through the commodity maize and soybean supply chains is expected. However, there is limited knowledge of the rate and extent of such grain dispersion. The limited experience from two recent testing programs for the identification of specific biotech events provides some quantification.

Case Study 1 Testing program following the inadvertent release of experimental event in the USA

Over a three year period, a total of 15 thousand hectares were inadvertently planted with an experimental maize event in the USA. At the time, these plantings represented less than 0.01% of the total USA maize hectares. In the five years following the discovery of the accidental release, nearly 100,000 grain samples were tested through PCR[14] detection methods for the presence of the experimental event. The majority of the samples were taken from barges and trains loading for export markets. A bit less than one per cent of all the tests performed were positive. Most positive detections and the largest concentrations of the experimental maize were observed in the first year of the testing program. The concentration of the experimental event in all samples that tested positive over the first 18 months of the testing program is illustrated in Figure 6. The content of the experimental event in those samples that tested positive ranged from 0.10% - 1.70% with an overall average of 0.14%.

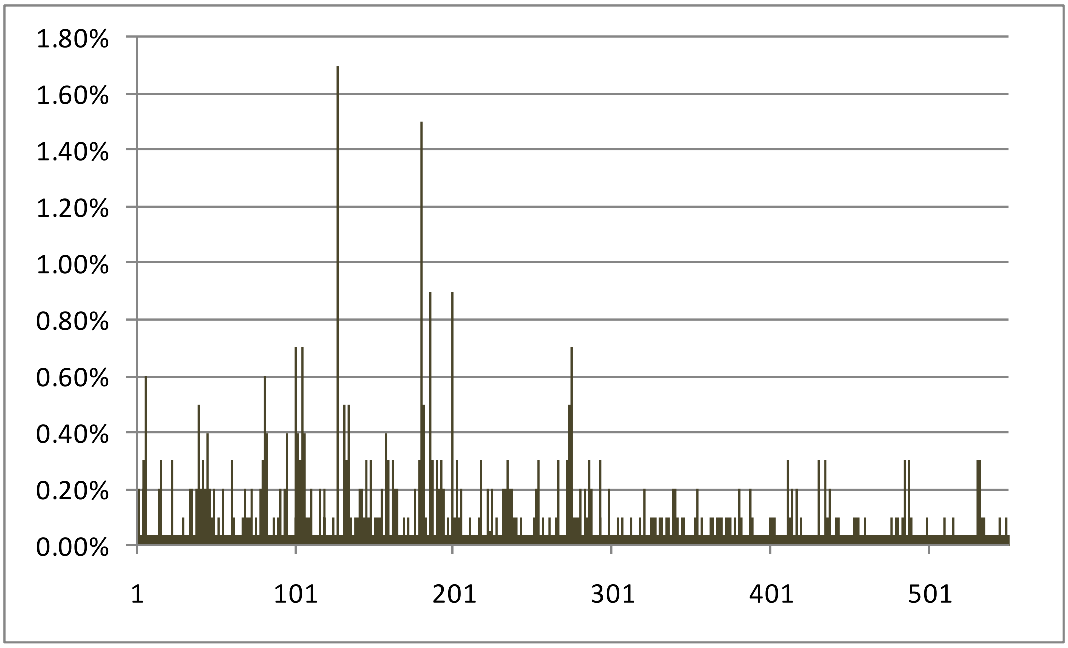

Figure 3.6: Concentration of the experimental event in positive tests
Source: Authors' calculations from original data

---

[14] Polymerase chain reaction (PCR) is a technique for isolating and amplifying a fragment of DNA via enzymatic replication. It enables the detection of specific strands of DNA by making millions of copies of a target genetic sequence, simplifying its visualization. The process necessitates lab work making it relatively slow and costly. However, its advantage is that PCR can either be qualitative or quantitative, the latter being more common as it can determine whether a DNA sequence is present in a sample and the number of its copies in that sample –i.e. the proportion of GMOs in the sample. PCR is often employed as an event-specific test, searching for the presence of a DNA sequence unique to a certain GMO. This approach is ideal to precisely identify a GMO, yet highly similar GMOs will pass completely unnoticed. Alternatively, it can be used to identify certain construct-specific DNA sequences that are shared by several GMOs.

> *Case Study 2 Testing program for channelling unapproved event away from EU imports*
>
> The most broad-based channelling program to be attempted so far was put in place in the USA during the 2006/07 marketing year in order to keep the newly introduced maize event DAS 59122-7 (Herculex Rootworm) away from the corn gluten feed supplies destined for the EU feed market. In 2006, approximately 336,000 hectares (or roughly 1% of total USA maize area) were planted with Herculex maize which was approved in the USA, Japan, Korea and elsewhere but not in the EU (a case of asynchronous approval). In anticipation of possible trade disruptions, the seed suppliers, the National Corn Growers Association, the USA Corn Refiners Association, and EU importers (represented by COCEREAL and FEFAC) jointly developed a plan designed to keep EU CGF imports free of the unapproved event. The plan called for coordinated deliveries of Herculex maize to dedicated storage facilities and broad based testing of barges destined for export markets. Barges that tested positive were to be diverted to the domestic market or other export markets where Herculex was approved.
>
> Despite the small level of adoption, the use of dedicated storage facilities, and efforts to manage and segregate product flows, almost half of all sampled barges tested positive for traces of DAS 59122-7. Specifically, a total of 2079 protein tests were taken of which 1134 were positive (54.5%). For 188 of the barges that tested positive, PCR tests were also performed. For 134 of those tests, the content of the unapproved event could not be quantified (due to harsh conditions in production and drying of CGF) while for 54 the amount of the unapproved event ranged from 0.1% to 16% with an overall average of 2.6%.[15]

The two case studies above indicate a pattern of broad geographic and temporal dispersion of grain at low levels throughout the supply chain even from a small acreage base or in the presence of segregation efforts. The recognition that such low level admixtures can occur throughout the maize and soybean supply chains underlies the allowances made for adventitious presence (AP) of authorized GMOs in the EU’s mandatory labelling laws, in the various commercial “non-GMO” programs, as well as in the EU’s organic grain standards.

3.4.4 Segregated supply chains

In segregated supply chains a primary objective is to ensure the absence of non-conforming grains from all final products. This implies that the non-conforming grain must be avoided at each and every part of the supply chain. For this purpose, segregated supply chains use both prevention and remediation.

Prevention of admixtures in segregated supply chains
Prevention of admixtures requires re-engineering of the standard production, storage, processing and distribution processes normally used in commodity supply chains. In fact, segregated supply chains must often reach beyond the farm to ensure the purity of planting

---

[15] It is also interesting to note that despite negative tests in all export shipments of CGF at USA ports, several tested positive upon arrival to the EU. In all, eight notifications for DAS 59122-7 were submitted to EU competent authorities until the trait was approved in September of 2007 (2008 RASFF).

seeds. A variety of interventions that seek to prevent admixtures in segregated supply chains can be used:

- *Seed* – Seed companies use stringent management practices (e.g., minimum allowable distances between fields, buffers, identity preservation, seed lot inspections and testing) and produce seeds with high purity levels. Nevertheless, seed production occurs in open environments and cross-pollination or inadvertent commingling with other varieties during planting, harvest, transport and conditioning can occur at low levels (Kalaitzandonakes and Mangier, 2004). Segregated supply chains may therefore require additional testing and certification of seeds prior to planting.
- *Field* – Admixtures can occur during crop production through cross pollination and presence of volunteer crops in the field. Use of geographic and temporal isolation of production (e.g. buffer zones), border rows and other physical barriers can reduce the incidence of cross-pollination from neighbouring crops (e.g. Bullock and Desquilbet, 2002, Devos et al., 2005). Various methods for the control of volunteer plants in production fields exist and may be used when necessary (ibid)
- *Farm Equipment* – Admixtures in grain can occur during planting and harvest as farm equipment is typically shared among different grains, fields and often farms (e.g. through contract harvest services). Meticulous cleaning of planters and harvesters, load “flushing,” or use of dedicated equipment maybe used to minimize the chance of such admixtures (e.g. Bullock and Desquilbet 2002, Wilson and Dahl, 2005).
- *Transport/logistics* – Grains are typically transported multiple times and through multiple modes (truck, rail, barge and/or vessel). Meticulous cleaning is typically used to limit the possibility of inadvertent commingling of grains during shipping.
- *Storage* **–** Grains can commingle with foreign dust and grain remaining in storage. Careful lot management and meticulous cleaning of dumping pits, conveyors, augers and other mechanical systems, as well as in storage bins or the use of dedicated equipment and facilities are used to reduce the chances for commingling of grains in vertical storage (Kalaitzandonakes and Maltsbarger, 2000, Bullock and Desquilbet, 2002, Wilson and Dahl, 2005). Segregation in flat storage is more difficult and dedicated facilities maybe needed.
- *Processing facility* – Since cleaning processing facilities is difficult and costly, segregation in processing normally requires the use of dedicated lines or dedicated facilities altogether (Kalaitzandonakes and Kaufman, 2006).

Remediation and Testing

In addition to prevention, segregated supply chains use remediation when admixtures occur despite preventive measures. Through repeated testing they seek to identify accidental admixtures thereby isolating non-conforming grain before entering the segregated stream or redirecting commingled lots back to the commodity supply chain. Testing can occur at different parts of the supply chain but, most frequently, when there is a change in the custody of the grain.

To be effective, testing must not greatly interfere with the operational efficiency of the supply chains; it must not lead to erroneous results (false positives or false negatives); it must discourage cheating; and it must be cost effective. In all cases, there are trade-offs between testing costs and risks from sampling and analytical uncertainty (Kalaitzandonakes, 2006) and these factors are taken into account when firms design their strategies and decide where to test, how much to test and what test to use (Wilson and Dahl, 2006; Konduru et al., 2009).

3.5 The costs of segregation

Changes in the normal supply chain operations to prevent admixtures as well as testing and remediation typically imply additional costs (relative to commodity chains). There are both direct and indirect segregation costs (Kalaitzandonakes et al., 2001). Direct segregation costs are payable costs and result from:

- *Re-engineering of operations*: As firms adapt their operations throughout the supply chain they can incur extra capital, labour and material costs (e.g. extra labour for equipment cleaning during planting, harvest, storage and processing; extra capital for dedicated equipment, etc.).
- *Coordination and control*: segregated supply chains require more market coordination resulting in higher transaction costs (e.g. extra management time, contracting costs, testing costs, third party certification fees, and others).
- *Liabilities and product failures*: segregated supply chains involve unique risks and liabilities when prevention and remediation fail to keep non-conforming grain away from segregated supply chains (e.g. demurrage costs, costs of product failure and product recalls, costs of dispute resolution, etc.). When insurable, such risks and liabilities translate into payable costs in the form of premiums.

Indirect segregation costs are non-payable costs. They are opportunity costs which result from efficiency losses through underutilization of production, storage and transportation assets as well as foregone profits (e.g. unrealized profits from higher yielding biotech crops not planted or from grain blending not performed in large elevators, etc.; (Maltsbarger and Kalaitzandonakes, 2000; Bullock and Desquilbet, 2002).

Segregation costs are not fixed. They can vary significantly: from one part of the supply chain to the other (Borchgrave et al., 2003); across commodities;[16] with the physical configuration of the supply chain (Kalaitzandonakes et al., 2001, Bullock and Desquilbet, 2002, Wilson and Dahl, 2005); across regions; and over time.[17] Because of such heterogeneity and the limited experience with such systems, it is difficult to fully characterize the structure of segregation costs or produce an “average segregation cost.” Nevertheless, the impacts of some key drivers are well understood and the direction of those impacts is reasonably predictable.

- *Segregation costs increase as purity standards and AP tolerances decrease*: The rigor with which segregation procedures are designed and implemented depends mostly on the desired level of purity. For segregated supply chains with low AP thresholds, strict measures designed to prevent even traces must be put in place. Low AP thresholds also mean additional testing and greater amounts of product failures (Bullock and

---

[16] Commodities differ in their production systems, supply chains, and end uses. Because of idiosyncrasies, segregation costs can vary substantially across commodities. For instance, while outcrossing control may require expensive measures in the production of cross-pollinating maize it is a minor issue for self-pollinating soybeans. Similarly, testing costs might be significantly higher in non-GM maize program than in soybean ones due to greater amount of events that one must test for.

[17] Variation in input and commodity prices alone can lead to significant spatial and temporal variations in segregation costs. For instance, large swings in commodity and input prices imply significant changes in the opportunity costs associated with foregone yields and efficiency losses in the production of segregated grains.

Desquilbet, 2002; Kalaitzandonakes and Magnier, 2004, 2006). Beyond certain levels, as thresholds diminish, segregation costs increase exponentially (Kalaitzandonakes and Magnier, 2004, 2006).

- *Segregation costs increase as the scale of production of non-authorised grains increases*: With increasing acreage allocated to EU non-authorised grains, accidental admixtures are more difficult to avoid and adventitious presence tends to increase. Under such conditions, firms all along the segregated supply chain must implement more rigid segregation processes to meet purity thresholds and incur rising costs.

3.5.1 How high can segregation costs be?

In addition to being complex and idiosyncratic, segregation costs are difficult to size because of the limited empirical evidence available (Table 3.1).

The few studies that have measured segregation costs have concentrated on specific parts of the supply chain (e.g. seed: Kalaitzandonakes and Magnier; agricultural production: Bullock et al.; elevator: Maltsbarger and Kalaitzandonakes; processing: Kalaitzandonakes and Kaufman, 2006). There are only a handful of studies that provide estimates on how IP costs accumulate through the whole chain. Borchgrave et al., 2003 reported that IP costs for non-GMO soybean marketing chains with 1 per cent AP tolerance levels average €25.47/metric ton at the point of import. Similarly, the Canada Grains Council put average IP costs for non-GMO bulk shipments with 5 per cent AP tolerance levels at €9.06/metric ton and those with 2 per cent AP tolerance at €28.30/metric ton.

Comparisons of segregation costs across different studies are also problematic. Most estimates of segregation costs are for particular years, locations, and for specific crops (mostly wheat, maize, soybeans, and canola). Hence, it is not clear how each of these factors contribute to their observed variation. Additional variation in the size of segregation costs is introduced through the use of alternative measurement methods (budgeting, simulation, surveys of supply chain operators) which often account for different cost components and are typically not directly comparable. Even more critically, there is very limited evidence on the conditioning impact of AP thresholds on segregation costs, since most studies have calculated segregation costs for a given AP threshold or without explicitly using a threshold at all.

Some additional insight on segregation costs may be gleaned from examining the "premiums" paid by buyers in commercial non-GMO programs. These are generally strict segregation programs with markets of some size that have existed for over a decade. Under excess demand conditions, premiums may be quite different from the underlying segregation costs. Nevertheless, since segregated non-GMO markets are competitive and rather stable in size, segregation costs and premiums paid by buyers will tend to converge in the long run.

Table 3.1: Estimated segregation costs in the North America, various studies

Authors	**Cost Range €/t**	**Cost/Crop Price**	**AP Threshold**	**Crop**	**Year**	**Location**	**Part of supply chain**	**Analytical Method**
Hurburgh 1994	2.31-9.26	2%-9%	NR	Specialty maize	1994	USA	Country Elevator	Budget
Nelson et al. 1999	2.77-7.78	3%/4%	NR	Maize/soybeans	1999	USA	Grain Handlers	Survey
Linn et al. 2000	8.81/20.20	12%/12%	NR	Non-GM maize/soybeans	2000 (1998 data)	USA	Country, Subterminal, Export elev.	Survey
Maltsbarger et al. 2000	6.41-14.82	9%-20%	5%	HOC maize	2000	USA	Elevator	Simulation
Smyth et al. 2001	7.62-9.79	3%-4%	NR	Specialty/Non-GM canola	2001 (1995 data)	Canada	Farm/Grain Handlers	Case study
Kalaitzandonakes et al. 2001	3.89-20.20	5%-26%	5%	HOC maize	2001	USA	Elevator	Simulation
Bullock et al. 2002	0.07 3.56/1.00	0% 4%/1%	NR	Non-GM maize and Soy	2002	USA	Farm (Cleaning) & Elevator (testing)	Budget
Dahl et al 2002	9.57-19.15	7%-14%	NA	Specialty wheat	2002 (1996 data)	USA	Farm to Mill	Survey
Huygen et al. 2004	9.23-18.14	5%-11%	1-5%	Non-GM wheat	2004	Canada	Farm to Export	Budget/Simulation
Kalaitzandonakes et al. 2004		9%-35%	0.3-1%	Non-GM maize planting seed	2004 (2003 data)	USA	Seed	Simulation
Miranowski et al. 2004	14.58/17.14	13%/6%	NR	Non-GM maize/soybeans	2004 (2002 data)	USA	Grain handlers	Survey
Carter et al. 2005	2.53-4.13	1%-2%	NR	Non-GM wheat	2005	USA		
Wilson et al. 2005	12.61-25.22	7%-15%	NR	Non-GM wheat	2005	USA	Elevator	Survey
Wilson et al. 2008	29.23	7%	0.9%	Traceable non-GM wheat	2008	USA	Farm to Importer	Simulation

There are two main markets for non-GMO maize and soybeans, Japan and the EU, and two main suppliers, the USA and Brazil. Using information from various industry sources we can approximate the average premium paid by buyers of non-GMO maize and soybeans. We concentrate on the premiums paid for non-GMO supplies in the USA market, as this market is more transparent, allowing premiums to be observed over a longer period of time.

Case Study 3 Non-GMO premiums in the USA

Despite the extensive and rapid adoption of GMOs, the USA has been for years a significant exporter of certified segregated non-GMO maize and soybeans. While official statistics are not maintained, we estimate that in 2009 the USA exported roughly 2.5 mln t of non-GMO maize and 1.3-1.5 mln t of non-GMO soybeans. The primary markets for USA non-GMO exports are in Japan and Korea while there are secondary markets in Taiwan, the EU and in other countries.

Most USA non-GMO programs make allowances for accidental admixture of GMOs through AP thresholds. These vary with the needs of buyers and market requirements (e.g. mandatory labelling standards, consumer demand). Most non-GMO programs in the USA include adventitious presence thresholds of 0.9% - 5%.

Premiums can vary substantially within a growing season, by contract type, the AP threshold used (and hence the required segregation protocols), the availability of non-GMO supplies in the region and other factors. While recognizing the inherent variability, we find that average USA non-GMO premiums have increased in recent years, but premiums for maize and soybeans have followed somewhat different paths (Figure 3.7).

Maize premiums remained relatively stable until the mid-2000s and increased rather quickly since 2005. The period of growth coincides with the accelerated introduction of numerous new biotech traits and stacks as well as the doubling in the overall level of biotech maize adoption. There is empirical evidence of increasing productivity gains from this expanded portfolio of biotech maize hybrids which would imply an increase in opportunity costs for non-GM maize. As well, segregation operations throughout the supply chain should have become more costly as the chance of commingling and AP increased along with the adoption level of biotech hybrids. Such incremental costs would therefore be consistent with the elevated premiums observed over this five-year period.

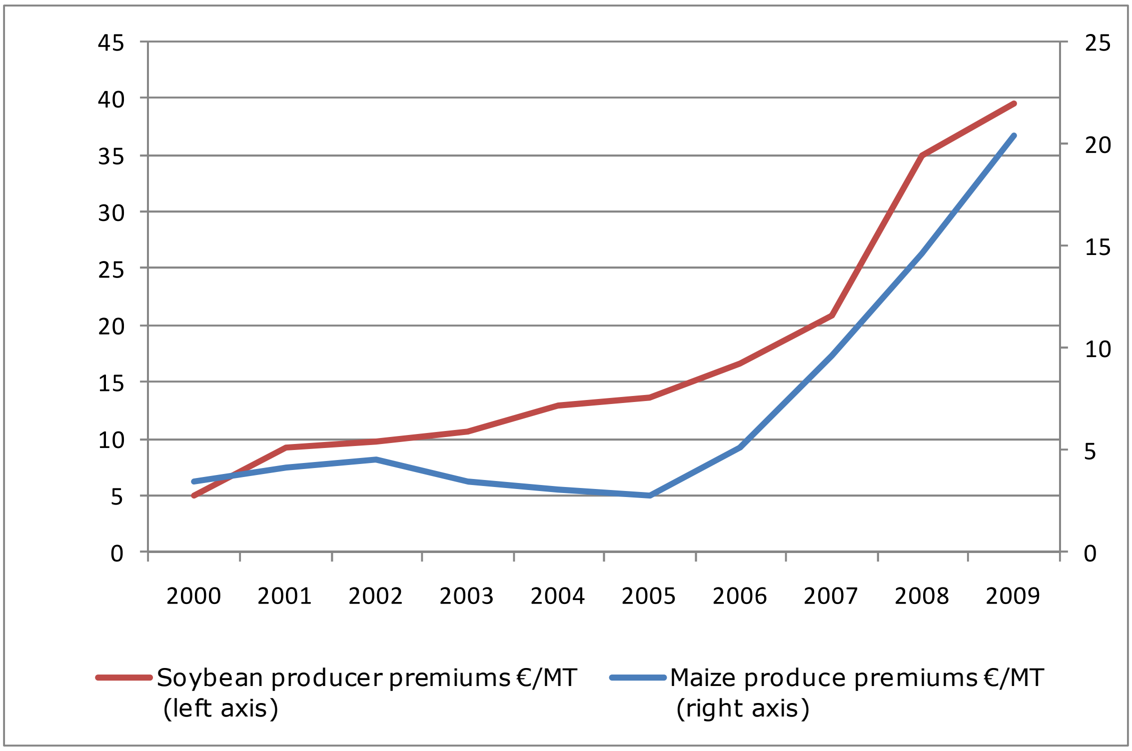

Figure 3.7: Average producer premiums for non-GMO USA programs
Source: Authors estimates based on information from industry sources

Soybean premiums increased slowly between 2001 and 2007. Over this period, a single trait dominated the market, Roundup Ready soybeans, and hence opportunity costs associated with the use of biotech should have been largely unchanged. Segregation costs, however, should have increased in parallel with the gradual growth in overall biotech soybean adoption. Observed trends in soybean non-GMO premiums between 2001 and 2007 are therefore consistent with expectations and, likely, reflective of segregation costs. Supply shortages in 2008 and 2009 were behind the observed abrupt jumps and hence premiums likely exceeded segregation costs in these two years.

Several useful conclusions may be drawn from the observed trends in the USA non-GMO premiums. First, expressed as percentages over the observed farm price of the commodity, premiums represented roughly 5%-15% increments over the 2001-2009 period. Second, expressed either in levels or as percentages, premiums are similar to the segregation costs reported in the literature (see Table 3.1). In this way, they seem to provide some confirmation for the validity of the few estimates of segregation costs provided in the literature. Third, the observed premiums suggest for AP thresholds of 0.9%-5% segregated chains can function at reasonable incremental costs, even amid heavy use of GMOs. Fifth, the observed premiums also emphasize that even with modest relative cost increases, the total incremental costs can quickly add over €75 million for Japanese buyers in 2009, for instance. Finally, the observed premiums, along with available estimates of segregation costs in the literature, serve to emphasize how little is currently known about the potential segregation costs for regimes of low AP thresholds.

3.6 Capacity for segregation in the key exporting countries

Given our general understanding of how segregated supply chains operate, the factors that determine their effectiveness and the extra costs they can imply, we may now examine whether key exporting countries can ensure the absence of unapproved events in EU maize and soybean imports at a reasonable cost. In this respect, we examine certain characteristics of the maize and soybean supply chains in the USA, Argentina, Brazil, Uruguay, and the Ukraine in order to determine their capacity to consistently segregate regulated and non-regulated grains.

Upon close examination, maize and soybean supply chains in the key exporting countries display similar characteristics. First, the production locations for maize, soybeans, but also other key crops like wheat, rice, and canola greatly overlap. There are a number of physical factors that determine the geography of crop production. These include: climate (rainfall, temperature, sunlight), pests (insects, disease) and soils (structure, chemistry). A favourable balance of these conditions – moderate temperatures, frequent rainfall, plentiful light, and rich deep soils – determines the location of broad-acre crops. In the USA this is largely in the Midwestern plain states, the Cerrado in Brazil and the Pampas in Argentina. The overlap in the production land base of the key crops in all exporting countries suggests that admixtures and commingling of grains of various origins are expected. Admixtures across commodities (e.g. maize dust in soybeans or in wheat) are also possible under these conditions.

Second, key infrastructure is located in the key production regions and broadly shared across crops and firms. Our review of the trading infrastructure in the key maize and soybean exporting countries reveals a complex network of limited storage, transport and processing resources that has been built over decades with emphasis on maximizing efficiency and minimizing costs. Large facilities maximize economies of scale by handling large volumes while aggregating and commingling of grains from various origins create continuous grain flows that maximize capacity utilization. As storage, ports, train depots and other infrastructure must be broadly shared, they become critical control points for the supply chains in all key exporting countries. Admixtures and commingling of grains of at such critical control points are expected.

Third, spatial and temporal patterns of biotech adoption in all key exporting countries indicate that conventional and biotech crops will coexist and spatial separation would be unlikely. Hence, admixtures of conventional and biotech crops is expected. In all, past patterns of crop production, GMO adoption and the normal operations of maize and soybean supply chains in key exporting countries all suggest that the strictest of segregation systems would need to be implemented in order to minimize the presence of EU non-authorised maize, soybeans and processed products. Past experience also suggest that even with the strictest segregation systems in place preventing consistently admixtures of EU non-authorised grains would be unlikely and costly. Yet in the long run, segregation programs would likely prove unsuccessful due to unique challenges in remediation and because of the implied excessive liability and failure costs.

3.6.1 Testing for unapproved events and remediation in segregated supply chains

As discussed above, strict segregation programs depend on rigorous supply chain controls and repeated testing at all critical exchange points to ensure the absence of non-conforming grain. For a number of the critical supply chain points, protein (strip) tests must be used. Strip tests are inexpensive (€1-€4 depending on volume and vendor) and can be quickly and easily performed under field conditions. Hence, they are essential for keeping segregation costs manageable while allowing the continuing operations of the supply chains. For instance, trucks arriving at storage or processing facilities must be tested before they can unload their cargo. These testing procedures can be effectively managed only with quick protein tests that involve minimum time delays. PCR tests are expensive (€100s depending on volume and vendor) and require laboratories as well as long waiting periods (days) to return a reading. Hence, PCR tests cannot be used at such critical points in the supply chain where continuous flow of grain must be achieved.[18]

Yet, quick protein tests may not be available for certain new GMOs, making large scale segregation programs for these products, practically, unfeasible. Specifically, strip tests may not be available when proteins in new and/or second generation traits are not novel. For instance, Monsanto’s Roundup Ready soybeans and the second generation Genuity Roundup Ready2 soybeans both express the same CP4 protein and hence a DNA test is necessary to distinguish the new event from its first generation counterpart. Strip tests would also not be usable in cases where new traits do not readily express a novel protein. For example, Pioneer's Plenish high oleic soybean does not express a novel protein at all and would also require DNA testing.

Testing procedures, and in turn segregation programs, can also be complicated by the differential regulatory treatment of stacked traits in different countries. Situations where large stacks may be approved but smaller stacks or individual traits do not have full approval complicate separation and testing. For instance, a stack with 4 traits may have received regulatory approval but any of the singles or double or triple combinations of the same traits may not have full approval. In grain it would not be possible to distinguish between approved and unproved events by testing.[19]

---

[18] It is possible that at some point in the future, real time inexpensive DNA tests will be available and can facilitate practical and less costly segregation. However, given the current state of technology and the time frame of the analysis, such potential innovations are not considered relevant.

[19] For example, a company gets approval for and launches trait ABCD, trait A, and trait ACD. In some world areas B or C individually are regulated. Yet testing grain would be impossible to determine if B by itself, C by itself, BC or ABC were mixed into the grain.

3.6.2 Failure risks and costs

Since there are no allowances for unapproved events in imports to the EU (zero tolerance) there are also higher failure risks and costs. Failure risks correspond to the chance that segregated supplies considered free of unapproved biotech events test positive at some part of the supply chain. Costs from such a product failure would likely be manageable as long as the failure occurs within the borders of the exporting country. Non-conforming supplies can be redirected to the commodity supply chain with a significant salvage value still in place. If the product failure were to occur at the point of import or beyond, however, product failure costs would quickly mount. Because of legal liabilities and significant multiplier effects, economic losses from such failures tend to be disproportionately high relative to the initial value of the delivery, whether failure occurs prior to entering the EU food and feed chain or afterwards. [20]

The expected outcome of increased failure risks and costs is immediate suspension of segregation operations and trade[21]. Importing and exporting firms engaged in such trade are expected to act rationally and avoid potential damages that are disproportionally higher to the potential profits from such transactions. This type of market behaviour can be readily observed in the few instances when failure risks and costs increased in the presence of unapproved GMO events that could not be effectively kept away from export markets, like in the following case study.

> *Case Study 4: Trade Behaviour in the Presence of Unapproved Events*
>
> Figure 3.8 illustrates the EU monthly imports of corn gluten feed from the USA over the 2005-2009 period. As discussed in case study 2, in 2006/07 importers and exporters of CGF cooperated to keep supplies containing the, then, unapproved DAS 59122-7 away from the EU market. Yet, repeated positive tests both at origin and destination in late 2006 and early 2007 indicated the limited success of the program. The immediate impact on CGF trade is readily apparent as monthly exports abruptly declined over the same period. Imports restarted briefly following the approval of DAS 59122-7 in September of 2007 with “old crop” CGF imports from the USA. However, they stopped once again as harvest of the “new crop” that included two new unapproved GMOs – MIR 604 and MON88017 – picked up in the fall of 2007. It is expected that such economic behaviour will be consistently observed in the market.

---

[20] For examples of failure costs from importation of grains containing unapproved events in the EU see Backus et al., 2008; CIAAA, 2007; FEFAC 2008

[21] See Magnier et al., 2009; Toepfer International Market Review 2008.

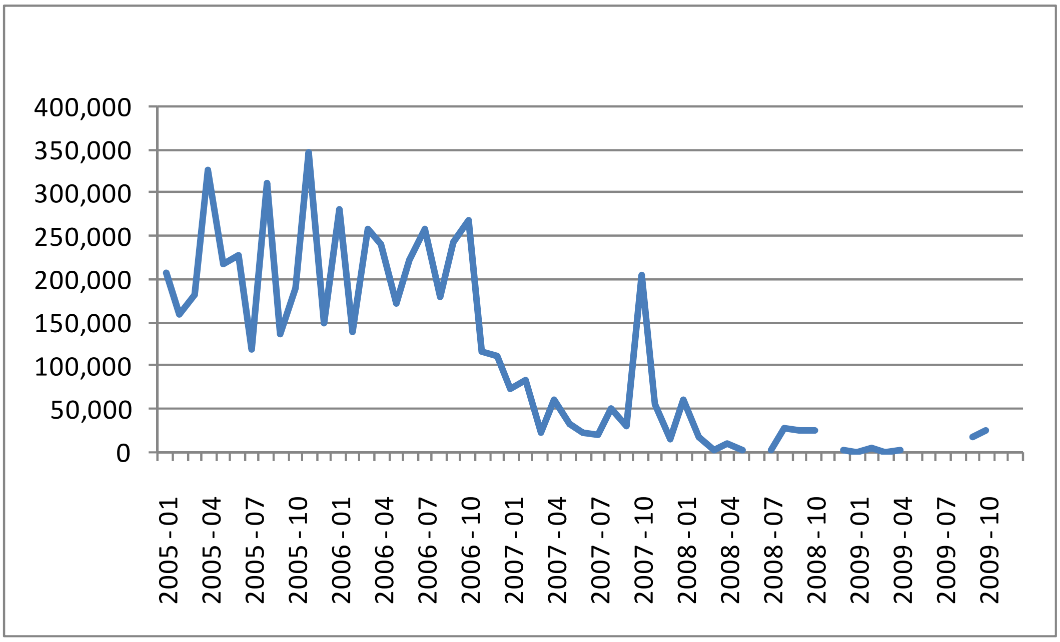

Figure 3.8: Impact of unapproved GMOs on EU maize gluten feed trade with the USA, in mln t.

3.7 Conclusions

Based on the analysis presented above we conclude then that in the absence of…

a. large and predictable supplies of conventional or EU non-authorised maize and soybeans;
b. effective, inexpensive and rapid testing methods for all unapproved GMOs in production;
c. adequate thresholds for adventitious low level presence of unapproved GMOs;

…segregation programs are unlikely to provide long term steady supplies of approved feedstuffs that will effectively satisfy a meaningful share of the EU's demand. Strict segregation programs may still prove adequate for keeping EU imports free of some unapproved events for limited periods of time. Hence they may prove useful in minimizing trade disruptions in cases of short-lived asynchronicities for certain biotech events.

It is also worth noting that disruptions of trade from inadvertent releases of experimental GMOs or illegal adoption of unapproved ones are likely and cannot be managed through segregation programs as they are not anticipated. Nevertheless, the very same elements of grain trade that present challenges for segregation programs also provide insight about the extent of low level presence and the potential trade disruptions that might ensue from unanticipated releases.

4 Possible disruption of EU livestock feed supplies

Willy Baltussen, Roel Jongeneel, Peter Nowicki, Coen van Wagenberg

4.1 Production and trade of maize and soybean

In Table 4.1 the world production of soy and maize is presented for the period 2007 until 2020. Forecasts of FAPRI[22] show an increase in the production of both soy and maize of 15% between 2010 and 2020. This increase is expected in the present main production areas being Argentina, Brazil and USA and for maize also in China and EU-27. The increase of the export of soy in the main production regions almost equals the increased import of China in the period 2010-2020. This means the share of China in the total world import of soybean will increase from 51% in 2010 to 60% in 2020. The increase of the import of soy in China is expected because of the expected increase of meat consumption in China going up from 56 kg in 2009 to 61 kg of meat in 2015[23]. For other countries importing soy, including the EU-27, almost no changes are estimated. The export market of maize is dominated by the USA and Argentina, Brazil and Ukraine follow. Main countries importing maize are Japan, Mexico, other Latin America and other Middle East. For Europe only a small increase in the import of maize (plus 0.2 million tonnes) is estimated by FAPRI for the period 2010-2020.

Table 4.1: Recorded[24] and estimated[25] production of maize and soy (in mln t) in the world by different most important countries.

Production areas	Soy production			Maize production			2019/2020	
	2007/08	2008/09	2009/10	2007/08	2008/09	2009/10	Soy	Maize
Argentina	46	32	53	22	13	17	63	23
Brazil	61	57	66	59	51	51	83	61
Paraguay			7				9	
USA	73	81	92	331	307	334	97	380
Ukraine	1	1	1	6	11	10		12
Serbia*				6	6			
China	14	16	14	152	166	155	16	188
EU-27			0.9	47	63	57	1	64
Subtotal	195	187	233	623	617	624	269	728
World	221	211	255	791	791	798	295	919
subtotal/world	0.88	0.89	0.91	0.79	0.78	0.78	0.91	0.79

**own research based on FAOSTAT*

---

[22] Food and Agricultural Policy Research Institute (FAPRI), a joint effort of Iowa State University's Centre for Agriculture and Rural Development (CARD) and the University of Missouri-Columbia's Center for National Food and Agricultural Policy (CNFAP). FAPRI uses comprehensive data and computer modelling systems to analyse the complex economic interrelationships of the food and agriculture industry.

[23] http://www.ats-sea.agr.gc.ca/asi/5546-eng.htm, accessed 13-09-2010

[24] Source: adopted from Toepfer International, February 2010, citing USDA (2008/09 are estimates; 2009/10 are forecasts)

[25] FAPRI, January 2010 USA and World agricultural Outlook.

4.2 Simulating the effects of a feed supply disruption

The scenarios for this study have been developed on the basis of information collected or generated in the first phase of the study, as reflected in the preceding chapters. Chapters 2 to 4 discuss different aspects influencing the future availability of EU approved GMO maize and soy, namely:

- GMO pipeline development (Chapter 2);
- Possible substitution in livestock feed composition (Chapter 2);
- IP reliability and possibilities for segregation of supply chains (Chapter 3);

The probability of a feed supply disruption is hard to estimate. Many different aspects discussed in the previous chapters influence the probability that a feed supply disruption takes place. Besides that, the existence of a small risk can also end the willingness to segregate in order to trade with the EU. Importing and exporting firms engaged in trade of feed products are expected to act rationally and to avoid potential damages that are disproportionally higher to the potential profits from such transactions. A third aspect is the period involved. A feedstuff supply disruption shock in the short term, from the perspective of 2010, has risks that differ in degree from similar risks in the long term (a cumulating number of new events, in view of the length of period of asynchronous approval).

The different aspects mentioned in the previous chapters interact. Introduction of new events in North and South America, given a certain approval policy of the EU, will increase the risks compared to introduction of an event in the USA only. The zero tolerance policy of LLP of GMOs in the material imported into the EU increases the risks for traders in areas where many GM crops are grown. The risks for trade distortion with the USA are therefore higher than with, for instance, Brazil.

A second aspect is that trade companies will only trade with the EU if risks are almost equal to zero. Given the fact of small profit margins, the lack of rapid, inexpensive and effective testing for unapproved GMO from approved GMOs, trade will be ceased in case not all GM crops are approved for importing in the EU.

The third aspect is the time line. In 2010, the number of GMO crops still is low, and trade disruption can be regarded as incidents. The trade of maize gluten feed between USA and EU, on the other hand, is a structural trade disruption (see case study 4 in Chapter 3). For this study two scenarios have been developed for 2012 (short term) and two on the time horizon of 2020 (long term), each containing a set of drivers, and each scenario having an estimate of the probability that it may become a reality in the different years. These scenarios are then used for the simulation of responses to incidental or structural situation of disruption in the supply of livestock feed to the EU from foreign suppliers, as might be brought about by asynchronous GMO approvals

The Takayama-Judge model referred to in Chapter 5 generates output on prices and volumes of maize and soy that reflect the evolution of trading patterns over the short run period of one to two years. The CAPRI model referred to in Chapter 6 generates output on the EU agricultural sector over the long run, on the order of five years or longer.

4.3 Description of the scenarios

To get insight in the impacts of different kinds of trade disruption, four scenarios have been defined. For both 2012 and 2020 two scenarios are defined based on the main drivers. For both years the scenarios contrast a low and a high impact on the import of soy and maize into the EU.

Table 4.2: Overview of the scenarios (more explanation is given in the descriptive text)

		2012		2020	
	Scenarios Drivers	*GREEN*	*ORANGE*	*BLUE*	*RED*
1	Number of incidents with LLP	Low (maximum once a year)	High (several times a year)	Low (maximum once a year)	None because trade is ceased
2	Temporary or structural loss of markets	Temporary loss of USA supplies	Structural loss of USA, Brazilian and Argentinean supplies	Structural loss of USA supplies	Structural loss of North and South American supplies, except Canada
3	Possibilities for segregation	*partial*[26]			
4	**Substitution possibilities**				
4a	Change in trade	Yes if possible	Possible to some extent	Realignment of trade. More import from South America	
4b	Change in feed production	No	Yes	Limited	Yes
4c	Change in feed composition	Yes, but temporary	Yes	Limited	Yes
4d	Change in livestock production	No	Yes	Limited	Yes

4.3.1 GREEN scenario *(horizon 2012)*

The GREEN scenario has a stylized character. It is assumed that an LLP incident takes place less than once a year, just like in recent years with some incidents of commingling (i.e., Hercules, L601 rice). Moreover, it is assumed that one supplier, notably the USA, cannot deliver temporarily to the EU market. As a result of this non-permanent shock, prices of soy on the world market will peak after such an incident[27]. Because these are only isolated incidents, no structural change is assumed to take place either in producing countries or in the importing countries (non-permanent shocks have non-permanent impacts). Substitution possibilities are limited to the change of ingredients of raw materials available on the internal market. A change in trade relations is also an option if stocks elsewhere in the world are high enough[28]. Given the expected short term impacts, no change in feed production in EU-27 or in the rest of the world will take place. Livestock production will also hardly be affected in

---

[26] Guaranteed segregation of approved and unapproved GMO within a country is regarded as impossible. Only segregation of non-GMO from (approved and unapproved) GMO is considered to be truly possible at a cost.

[27] see also results obtained by Burger et al., in preparation

[28] see also results from the T-J Trade model (section 4.2.1)

this scenario: it is likely that only feed prices will go up somewhat and perhaps feed quality will be a little lower. Since the shock concerned is a short run one, it is expected that commodity importers, crushers, feed industry, and farmers will bear the brunt of the impact, and that only to a limited extent the cost increase will be passed on to consumers. As argued by the study of Burger et al. (in preparation), the impacts on competitiveness are assumed to also be short run.

Within the scenario a distinction is made with respect to:
a. the moment in the year the incident takes place (USA is in season or out of season);
b. whether stocks in the southern hemisphere in the period considered are high or low.

Since the GREEN scenario considers a short run supply disruption somewhere within a year, the modelling tools used in the study, which all have an annual periodicity, are not directly applicable. Of the modelling tools used in this study, the T-J trade model, which has a short run character (see discussion in section 5.2.3), provides insights as to what may happen within the year following a feed supply disruption. However, in general the models available do not focus on within-year price variability, and they reflect equilibrium situations rather than (temporary) disequilibria or the adjustment process to a new equilibrium. For this reason the consequences of the GREEN scenario are analysed using a calculation scheme, which does not rely on economic models. However, in order to assess the impacts, results from both the qualitative and quantitative analyses in the study are used (including an assessment of past incidents, insights from the T-J model and the Burger et al. (in preparation) study).

4.3.1.1 Past incidents

In June 2009 traces of an unauthorized GM-maize event (MON88017) were detected in soymeal shipments from the USA to Germany (RASFF 2009.0716). In September 2009 traces of two unauthorized events of maize (MON88017/MIR604) were again detected in soy products from the USA destined to the Netherlands (RASFF 2009.1165). These two maize events were authorized in the EU on 30 October 2009 (MON88017) and 30 November 2009 (MIR604). Prices of soybeans in Rotterdam were about €30 per metric ton higher in the period June to December (average €348) compared to the period January-May 2009 (€317) and January-May 2010 (€318) (Figure 4.1, FAS-USDA, 2010). In this period, the stocks in South America were low due to drought in the previous growing season and increased demand from China. Prices for soybeans instantly rose after detection of the non-authorized events. After authorization took place, soybean prices dropped in two months by €31/metric ton. Similarly, prices of soymeal in Hamburg were about €35 per metric ton higher in the period June to December (average €335) compared to the period January-May 2009 (€309) and January-May 2010 (€295) (Figure 4.2, FAS-USDA, 2010). Prices of soymeal, however, increased already from April to May 2009, prior to the detection of the unauthorized maize events. After authorization, the soymeal prices dropped in two months by €23/metric ton. If stocks in South America would have been high, the price impact would have been lower. No data is available about the impact of higher stocks. In the calculation we have made, we assume that the price impact would have been half of the observed impact with low stocks.

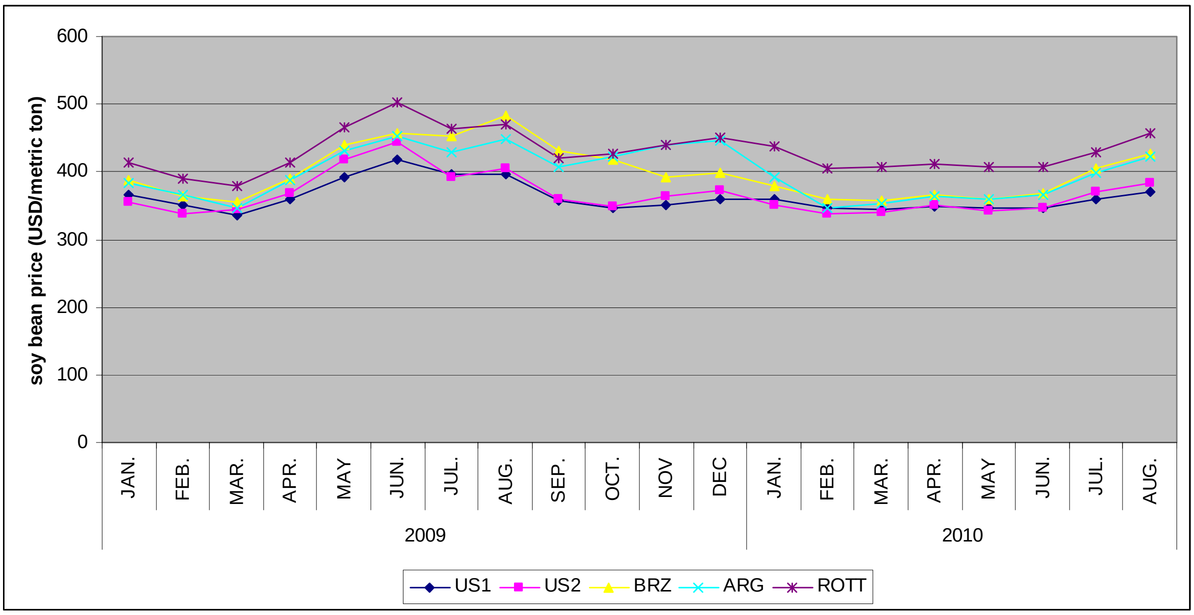

Figure 4.1: Soybean price from 2009-2010 in several locations.

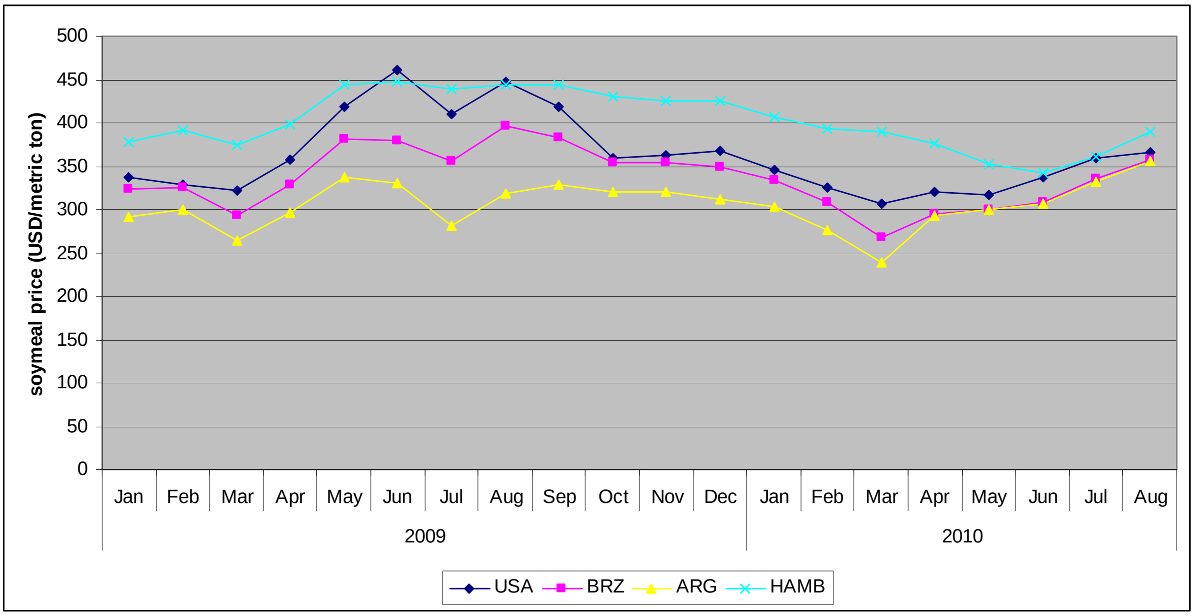

Figure 4.2: Soymeal prices from 2009-2010 in several locations.

4.3.1.2 Estimated impacts of the GREEN scenario

Sub-scenario (a): 3 month supply disruption in USA, while USA out of season

In sub-scenario (a) of the GREEN scenario, it is assumed that due to a supply disruption for a period of three months, the imports of soybeans from the USA will be impossible. The period considered is starting in June and ending in August. As in this period the EU does not import soy from the USA, no direct consequences concerning the import volume for the EU soy supply are expected. With respect to the situation of stocks in South America, the situation of either high stocks or low stocks is considered. If the stocks are high, sufficient soybeans and soymeal will be available. As a consequence, no change in feed composition is to be expected (no spill-over to third markets). This also is the case because soy is often bought through contracts. However, uncertainty about the length of the period drives up prices of soy for the EU. Therefore, based on the price increase of €31/metric ton observed in 2009, it is expected that in the low stock scenario soybean prices will increase by 5% and meal prices by 3.5% (see Table 4.3 results presented for sub-scenario (a). The EU is estimated to import 13 million metric tons of soybeans in the marketing year 2010/2011. For the three month period June, July and August, the imported amount is estimated at 3.25 million metric tons, a quarter of this amount. Because spill-over effects to third markets are expected to be minimal, no price increases for the other feed ingredient categories are likely under sub-scenario (a). With regard to variation of prices for soy, in the case of high stocks the estimated total direct feed bill costs are estimated to be €81 million, and in the case of low stocks this cost increases to €94 million.

Sub-scenario (b): 3 month supply disruption in USA, while USA is in season

In this scenario, where the USA is in season (November to March) and is exporting to the EU, the price increase estimates for soybeans and soymeal are again based on insights gained from the observed price changes in the two past incidents, as well as on some implicit results derived from the Burger et al. (in preparation) study. Although Burger et al. (ibid.) do not report their soybean prices as a result of blocking imports of soybeans from the USA, their model as well as the T-J trade model suggest that the price increase with a shock can be strong, although soon a correction will take place. This suggests that in a worst case – having a disruption when the USA is in season, whereas Latin America is more or less out of season and was also faced with a bad harvest year (e.g. low stocks) – the price increase might be much higher that what was recently observed in actual markets. Moreover in such a case, and seeing incidents more regularly happening, markets may become more nervous and the increased uncertainty may lead to overreaction. A counter-argument could be that the over-reaction might not be so strong; in the simulation of the BLUE scenario with the T-J model, it turned out that quick relocation of trade patterns is possible in the case of a USA soybean export disruption. (More details on this point are found in Chapter 6). As a result, prices will quickly return to values that are close to the initial equilibrium values. Taking all this into account, our best estimate is that there will be an impact on soybean and soymeal prices of 25 and 20 per cent, respectively (which is roughly double the amount that was observed in actual markets in September 2009).

Table 4.3: GREEN scenario: EU-27 feed bill costs due to a trade disruption with the USA of three month duration

	soybeans	soymeal	cereals	other oilseed meals	other feeds	by-product, additives etc.	total costs mln €
price $/t	400	300	230	200	200	180	
price €/t	300	225	172.5	150	150	135	
Sub-scenario (a) and low stocks in southern hemisphere (USA out of season)							
% price change	5.0	3.5	0.0	0.0	0.0	0.0	
price change (€/t)	15.0	7.9	0.0	0.0	0.0	0.0	
quantity (mln t)	3.3	5.8	17.7	1.5	3.0	5.9	
cost (mln €)	48.8	45.3	0.0	0.0	0.0	0.0	94.0
Sub-scenario (a) and high stocks in southern hemisphere (USA out of season)							
% price change	5.0	2.5	0.0	0.0	0.0	0.0	
price change (€/t)	15.0	5.6	0.0	0.0	0.0	0.0	
quantity (mln t)	3.25	5.75	17.7	1.5	3.0	5.9	
cost (mln €)	48.8	32.3	0.0	0.0	0.0	0.0	81.1
Sub-scenario (b) and low stocks in southern hemisphere (USA in season)							
% price change	25.0	20.0	10.0	15.0	10.0	2.5	
price change (€/t)	75.0	45.0	17.3	22.5	15.0	3.4	
quantity (mln t)	3.25	5.75	17.7	1.5	3.0	5.9	
cost (mln €)	243.8	258.8	305.3	33.8	45.0	19.9	906.5
Sub-scenario (b) and high stocks in southern hemisphere (USA in season)							
% price change	10.0	5.0	2.5	2.0	2.5	1.0	
price change (€/t)	30.0	11.3	4.3	3.0	3.8	1.4	
quantity (mln t)	3.25	5.75	17.7	1.5	3.0	5.9	
cost (mln €)	97.5	64.7	76.3	4.5	11.3	8.0	262.2

Because a short run shock is considered, it is assumed that neither farmers nor the feed industry have many possibilities for a change in feed composition or supplies. For that reason, the total amount of feed consumed can remain stable, with the assumption that sufficient substitution between feed ingredients is possible[29]. Some substitution by rapeseed meal, sunflower meal, palm kernel meal, cottonseed meal and also with cereals may occur, but this will be limited, because these commodities are also often bought on contract and stocks are not very high. Under the most conservative assumption with respect to substitution between feed ingredients, the monthly quantities for various feed ingredients used in the EU remain similar to those under sub-scenario (a). Now, however, not only is the price increase for soybeans and soymeal more significant than under sub-scenario (a), but also the spill-over effects to the price formation in other feed markets are considered. The potential for

---

[29] As is argued in the Burger et al. (in preparation) there might be a certain amount of substitution possible also in the short term out of the (private and public) cereal stocks kept in the EU. Unfortunately their study does not allow to assess the implied soybean price change of a scenario which comes rather close to our GREEN scenario. Note that when some degree of substitution will take place this is likely to push the price of the substitute up. Although the net effect will be a reduction in total feed costs per ton (compared to the situation with no substitution and an increase in the price of soymeal, due to this effect its magnitude might be limited.

substitution as well as nervousness in the market is assumed to create a tendency for the other prices to move in a parallel way to the prices in the soy market. The price increases in related feed ingredient markets are assumed, however, to be less pronounced (see percentage price changes for cereal, other oil meals, etc., as indicated in Table 4.3).

In the case of high stocks of soybeans and/or soymeal in the southern hemisphere and/or of high stocks of cereals in the EU, the price increase for soybeans and soymeal is estimated to be 10 and 5 per cent, respectively (see Table 4.2, sub-scenario (b): USA in season and high stocks in South America). Also, the spill-over effects to other markets are assumed to be more limited in this case. The estimated costs vary from about €906 million (low stocks and/or bad harvest in Latin America) to about €260 million (high stocks in Latin America).

The calculated costs under the various sub-scenarios reported in Table 4.2 are estimates at the EU-27 level. Given the specific short run nature of the supply disruption in the GREEN scenario, it is argued elsewhere that the livestock farmers are likely to bear the brunt of the cost increases[30]. Although no detailed modelling calculation has been possible, the projected soybean and soymeal net trade positions of EU Member States, as derived from the CAPRI modelling tool, could be used to assess how the costs will be distributed over Member States. Spain would be most impacted, with 17 per cent of the calculated costs accruing to Spanish livestock farmers. The livestock farmers in Netherlands and Germany would each bear 14 per cent of the costs. The shares of the costs for livestock farmers in France, Italy, the UK and Belgium would be 12, 10, 6 and 6 per cent, respectively. All other Member States would have shares in the calculated costs that are (much) below 5 per cent.

It should be realized that the calculations made above are based on quite a few assumptions. Note that the relatively restrictive assumptions with respect to substitution mean that the calculated effects have the character of an upper bound estimate. Allowing for more substitution will lead to more limited increases in costs than reported in Table 4.2, but feed costs will always be higher than when compared to the baseline situation. Although the assumptions try to use insights from actual market behaviour as well as of model studies, several uncertainties remain. However, it seems rather unlikely that the direct costs of a 3 month soybean delivery shock from the USA should exceed €1 billion, even in a worst case formulation of the GREEN scenario. An amount in the range of €250-300 million seems more realistic[31]. Note that the calculations only focus on the direct costs to the feed bill for the EU-27, but exclude indirect costs in related livestock markets or to consumers.

4.3.2 ORANGE scenario *(horizon 2012)*

A series of incidents take place in 2012 which makes the trade between the most important suppliers of soy (USA, Brazil and Argentina) to the EU impossible. The risks are too high for the trading partners to continue trade with the EU. Contracts are settled again leading to very

---

[30] As will turn out later in case of structural supply disruptions (see Chapter 6 for further details), part of the cost increase of feed will be passed on to consumers.

[31] To put the impact in perspective it could be noted that in 2008 the total value of feeds used by the livestock sector was estimated to be 89 billion euro. So the impact on the feed bill most likely will be less than ½ per cent of the total feed bill value, and even in a worst case version of the GREEN scenario not amount more than 1 per cent of the total feed bill value.

high prices in the short run and higher equilibrium prices for the next years (partly caused by the higher chain costs and by increased stocking costs in the remaining countries like Canada, Bolivia, Uruguay and Paraguay). Substitution possibilities are limited to the change of ingredients of raw materials available on the internal market (within the EU). Because problems seem to be structural (no signs that incidents can be avoided in the years to come), European producers will start changing the production structure (high compound and feed prices, lower level of animal production), which together lead to increased supply of meat on short run and decrease of supply in the long run depending on production cycles for each type of animal (Burger et al., in preparation). Driven by the changing market prices for feed and meat, structural changes in land use, feed production and animal production within the EU can be expected. Permanent shocks will lead to permanent impacts and adjustments.

With regard to maize, a similar situation would be that the import of maize supplies to the EU from the Americas was interrupted on a regular basis, therefore producing a similar reaction on the part of traders as for soy. This situation is set out in Table 6.2, and the implications are discussed throughout Chapter 6.

Box 4.1: Transition from GREEN to ORANGE scenarios *(horizon 2012)*, with regard to soy

The domestic demand for soybeans in China is growing rapidly, increasing by 9 mln t to 50 mln between 2008 and 2009, and set to increase another 5 mln t in 2010. Chinese use of soymeal for livestock feed has tripled in the past 6 years. Therefore, at the global level, there is a strong incentive to increase the amount of soybeans available for trade, either as beans or as meal, and producers are turning to GM soybeans in order to insure the enhancement of production capacity.

GM soybean plantings are currently at 77% of the total: 93% in USA, 99% in Argentina and 76% in Brazil for 2010, which together cover 83% of global production. These countries supply 89% of global soybean trade.

For the moment, all GM soybean seeds currently grown are herbicide resistant, and are approved by the EU for import. GM seed companies, however, have already made application for approval in most of the producing countries for new events combining herbicide and pesticide resistance and also in some cases adding a modified fatty acid composition or a higher Omega 3 fatty acid content. Planting is expected to begin in the USA already in 2011. In Brazil three new events have already been approved, and could be planted in 2011, two for herbicide resistance and one combining herbicide and insecticide resistance. Although these three events have been submitted to EFSA, the question is if these would be approved within the next 6 months; if not, then a decision by Brazilian producers whether to plant these or not would confront the risk of an EU embargo because of the zero tolerance threshold for non-approved events. Seed purchases, however, are being decided by producers at the present time.

In Argentina, the legislation on intellectual property rights is being revised, and this will eventually oblige producers to pay royalties for GM soybean seeds, which means that there would subsequently be access to the new generation of GM events beyond the existing, and EU-approved, herbicide resistance trait. As the rate of adoption is the highest in the world, it is most probable that producers would rapidly seek to plant seeds with the new traits when they would be commercialised.

The preceding observations suggest that the probability for a structural change in the access of the EU to approved GM soybeans is changing rapidly, becoming likely even in the short term. The EU share of world soybean imports is 14%; it is the only GM importer with a zero tolerance threshold, and has a GM approval process that is known to be longer than that of other soybean producers and importers.

Source: based on the Toepfer International *Market Review* for September 2010 and information from the research for this study.

4.3.3 BLUE scenario *(horizon 2020)*

In the BLUE scenario the number of new events in different crops expanded quickly in the period 2015-2020, especially in the USA. The risks of LLP are too high to import feed ingredients from the USA and all trade of feed ingredients with the USA has been ceased. Trade with South American countries is still possible because fewer events are introduced and the approval of events in South America and EU are synchronized. New equilibriums in international trade markets and structural changes in EU (feed production, livestock production, feed composition) have taken place. Because trade with South America is still possible, change in trade partners (no USA, more Brazil and Argentina) will be the main solution for this scenario compared to the other livestock feed ingredient substitution options within the EU-27.

4.3.4 RED scenario *(horizon 2020)*

In the RED soy scenario all main producing countries of soy and maize (USA, Brazil and Argentina) have introduced many new events which are not all approved for import in the EU. Because segregation is not possible, the LLP risks are too high for trading companies to continue the trade between these countries and their neighbours (except Canada), on the one hand, and with the EU, on the other. (Canada remains isolated in terms of maize and soy trade with the rest of North and South America, maintaining trade only with non-GMO maize and soy importing countries, such as the EU.) This has become a structural problem. Changes in trade partners are possible to some extent (because all major producers are no longer able to trade with the EU). Within the EU all substitution possibilities, like land shifting from grazing to arable agriculture, yield increase, changing feed composition, and adapting the herd sizes will be used to come to a new equilibrium.

In the RED maize scenario an extreme supply disruption would be that in addition to the Americas also the imports to the EU from the Western Balkans would be disrupted, In this case, the reduction in imported maize would be on the order of 1.6 million tons. The reaction would be similar to the RED soy scenario, but less severe (see Table 6.2 for a comparison of the two RED scenarios).

4.4 Analysis of the probability of the scenarios

4.4.1 The factors influencing the analysis

Certain limits were set at the beginning of the study by the policy framework regarding the authorisation of GMOs in force at that time. As the study has progressed, specific conclusions from the thematic investigations have also imposed themselves. These are briefly summarised below.

In terms of the overall analysis of the probability of the scenarios, the following points are considered as given:

a. Present EU policy of approval and zero tolerance of unapproved GMO in imported products.
b. Expected increase in releases of new GMO events in several crops all over the world. First releases will be often in the USA and at least a half year later in South America (probably even later in Argentina).
c. High adaptation rates of new GMO events in all main soy and maize producing countries.
d. Seasonality of production and different crops with GMO events are cultivated in all main production areas of soy and maize in the world.
e. The impossibility to segregate GMO approved and unapproved products in production chains in all main exporting countries, because of the large quantities of soy and maize traded during almost the whole year; an economic model for these chains focusing on efficiency (cost reductions, efficient use of infrastructure); and the lack of an effective, inexpensive and rapid testing method for all unapproved GMOs in production.
f. Limited substitution possibilities in rearranging trade of feed ingredients, especially for soy or high protein products in the short run (not available at the world market) and to a lesser extent in the long run.
g. Substitution possibilities to change feed production exist within the EU in the long run:
    - In terms of the nutritional requirements of livestock, the possibility exists for the compound feed industry to replace most of the soy and maize for other ingredients, if these are available.
    - Price reactions can be expected, and have been estimated.

Furthermore, it is expected that for the short term:

1. Incidents with LLP of unapproved GMO will continue. Because non-permanent shocks will result in no structural changes, additional costs for the European livestock are estimated at €81 to €94 million depending if high or low stocks are available at world level in the case the incident takes place at the moment that USA is out of season. These costs increase to a level of €260 million (high stocks) and €906 million (low stocks) if USA is in season.
2. Incidents can occur several times a year resulting in a more or less structural trade disruption with high volatility in prices for feed and animal products within EU (See Burger et al., in preparation).

It is expected that for the long term:

1. An increasing number of new GM traits, with a strong tendency to be stacked, will become available to maize and soy farmers. With the anticipated arrival of new GM events patented by a variety of seed suppliers, the cultivation of GM crops probably becomes more attractive. A larger basket of events available to farmers is more likely to offer agronomic or economic benefits to farmers than the smaller number of events that is currently available. Moreover, the technology fees for GM seed may decrease when more suppliers of GM seed compete with each other, thereby adding to the attractiveness of GM crop cultivation. Two further considerations impose themselves, as set out in the following two points.
2. In the case of adoption of new traits, there is the possibility of an effect of diminishing returns. For instance, once a certain combination of herbicide tolerance and pest resistance has been achieved – along with the additional benefit of no-till cultivation in place – the additional incremental benefit from changing seed stock with similar types of traits will mostly lie in the level of royalties for the planting licenses. This is not the case when entirely new types of GM traits become available, such as drought resistance, increased nitrogen use efficiency and specific end-use related qualities.
3. The commercial interest of the specific end-use related qualities referred to in the previous point has the implication that some degree of output segregation is possible, but as the transformation of commodities to intermediate or final products is likely to remain close to the area of production, it is not to be assumed that segregation will necessarily need to go beyond the farm gate.
4. Because of the demand for cereals and oilseeds at the world level is increasing along with population and GDP – in light of changes in alimentary preference for more meat, and progressively for types of meat with lower conversion efficiencies than those displaced in consumer choice – the supply of maize and soy to the EU market will become a progressively lower share of world trade in these commodities. This means that the dependence on the EU market becomes progressively lower for any supplier.
5. Therefore, with the increasing occurrence of LLP incidents, traders may shift to a structural change in the GM composition of supplies of maize and soy products available for purchase, offering segregation simply between GM and non-GM, as suppliers will be oriented to the world market, in which a mixture of GM traits, old and new, becomes normative.

4.4.2 Conclusions related to the short term shock scenarios

GREEN

The situation here is that of a short term problem (i.e. an incident of 3 months duration) linked to LLP; therefore there will be no structural trade disruption.

Probability: High, almost inevitable, and could be worse than one incident per year, therefore creating part of the basis for the ORANGE scenario.

ORANGE

a) The case of 3-4 incidents from one supplier, each lasting 3-4 months, would be equivalent to a whole year of disruption, and therefore equal to a structural change (with regard to the specific supplier).

Probability: Rather high with regard to the USA in the case of soy, because of the number of resident companies involved with the development of new GM events, and the competition that this creates favouring innovation; this inherently leads to the BLUE scenario. In the case of maize, a quasi-permanent supply disruption from the USA to the EU already exists; the scenario would become a reality if a similar situation with regard to the rest of the Americas would occur.

b) If LLP incidents are coming from several suppliers, the nature of the LLP problem changes, because uncertainty goes up (now related to all suppliers).

Probability: The two South American countries included in the ORANGE scenario along with the USA can be considered separately.

- The legal and institution framework in Brazil encourages the introduction of events coming from the USA, and the development of events which correspond to domestic conditions. Thus there is a double pathway for the presence of new events. Given that the number of new events is increasing rapidly, LLP incidents are possible, even in the short term.
- Because Argentina no longer has direct access to new events from the USA – because of the lack of IPR protection for GM events at present – the introduction and use of new GM events will either occur illegally if coming from the USA (which is possible), or legally if other GM crop developers are commercialising their seeds without royalties (which is also possible). If, on the other hand, the legislation regarding the payment of royalties changes in Argentina, adoption patterns should be the same as in Brazil, and Argentina will take benefit of the research being done both in Brazil and the USA. In this case, the ORANGE scenario becomes increasingly possible with time. Because of the spread of GM innovation is likely to be rapid throughout the Latin American continent, the legalisation of royalties in Argentina would make the RED scenario highly probable.

4.4.3 Conclusions related to the long term shock scenarios

The long term situation with regard to supply to the EU depends on the types of GM events that will be commercialised. The previous discussion about the benefit to farmers of new traits, starting with herbicide tolerance and insect resistance, makes the point that releases of similar type of events (single or stacked) does not greatly add to what currently is already available to farmers, with the exception of an insect resistant soybean that will soon be released in Brazil for the first time. Marginal improvement becomes lower with the adoption of new events with herbicide tolerance or insect resistance, and this might slow down the introduction of new GMOs not approved for import into EU. Therefore adoption rates in general will keep going up, but a farmer's change between seeds, once the events are stacked, may go down. This may be the key difference between the BLUE and RED scenarios

BLUE

A structural problem exists only with the USA, because of both the high level of innovation leading to widespread adoption of new events and the fortuitous release of tested but non-commercialised events, resulting in their adventitious LLP impact in shipments to the EU.

Probability: Increases with the level of innovation, and ultimately becomes part of the basis for the RED scenario.

RED

The RED soy scenario denotes a widespread structural situation of asynchronicity in GM authorisation (and use) between North and South America (except Canada) and the EU. The RED maize scenario represents a similar situation for the Americas and the Western Balkans; it is more hypothetical than the RED soy scenario, as the Balkan Peninsula is politically closer to the EU than North and South America. The RED scenario reflects the assumptions that:

- adoption rates will be high,
- number of new events (also stacked) will increase,
- farmer uptake of new events may decline with time, but is still motivated by any innovation that corresponds to the requirements of specific end-users,
- the share of EU non-authorised GM material in the volume of supply flows will increase, therefore going beyond LLP situation.

Probability: High, almost certain. (At least for soy.)

5 Supply chain changes, effects on trade

Nicholas Kalaitzandonakes, Douglas Miller and James Kaufman

5.1 The Problem

Since asynchronicity in GMO approvals between producing countries and the EU could result in trade disruptions, we are interested in the consequences of such disruptions on the EU supplies and prices of maize, soybeans, and processed products. Because only the trade flows between the EU and specific exporters may be restricted, a model that explains bilateral trade flows must be used for quantitative analysis. Here, we use a spatial equilibrium framework.

5.1.1 Data

In order to render operational the spatial equilibrium model used in this study, detailed data on production, processing, consumption, trade flows, prices and costs (freight rates, processing costs), as well as tariffs and quotas for maize, soybeans, soymeal and soy oil in selected countries and groups of countries were collected or constructed.

Trade flows

Trade flow data was derived from the United Nations Comtrade database and this data set was validated and augmented by additional information on trade flows taken from Global Trade Atlas of Global Trade Information Services as well as from FAOSTAT-TRADESTAT. Each of these data sets is based on national customs data collected by origin and/or destination countries. Trade flows were collected by Harmonised System (HS) code for the principal maize and soybean commodities analysed, and these are reported in Table 5.1.

Table 5.1: Commodities used in the analysis

Commodity Name	HS Code
Soya Beans, Whether Or Not Broken	120100
Soya-Bean Oil Crude, Whether Or Not Degummed	150710
Soya-Bean Oil & Fractions, Refined	150790
Soya-Bean Flour And Meals	120810
Soya-Bean Oilcake	230400
Maize Seed	100500

Detailed annual bilateral trade flow data for various countries was first aggregated into four commodities (soybeans, soy oil, soymeal and maize) and subsequently in selected country groupings. Initially, the data was collected for all available trading partners and where one dataset omitted a potential trading partner it was complemented with data from the other data sources to ensure that relevant trade flows were not excluded. Trade flow data was aggregated into 38 countries and country groupings yielding a symmetric 38x38 matrix of bilateral trade flows (Table 5.2).

Table 5.2: Countries and country groupings

EU25	European Union 25	IND	India
BRA	Brazil	JAP	Japan
ARG	Argentina	TLD	Thailand
USA	United States of America	SKR	South Korea
CHN	China	INDO	Indonesia
PAR	Paraguay	MLAY	Malaysia
CAN	Canada	PHIL	Philippians
MEX	Mexico	ANZ	Australia and New Zealand
BUR	Bulgaria and Romania	MOR	Morocco
WBA	Western Balkans	TUN	Tunisia
REU	Rest of Europe	ALG	Algeria
RUB	Russia and Belarus	EGY	Egypt
UKR	Ukraine	TUR	Turkey
CAM	Central America	ISR	Israel
VEN	Venezuela	LDC	Least developed Countries
CHL	Chile	AFR	Non-LDC African Countries in the ACP
URU	Uruguay	C&P	Non-LDC Caribbean and Pacific Island countries in ACP
BOL	Bolivia	MIDE	Middle East (Syria, Iran, Iraq, Saudi Arabia, UAE)
RSA	Rest of South America	ROW	Rest of World

Source: CAPRI user manual, reflecting standard contraction of the regional framework within the model such as BUR for BUlgaria and Romania

As the data reported by origin countries and destination countries did not always match, the maximum value of the two reporting countries was taken for the final trade flow. Trade flow data was available in both volume and value. Although volume was of primary interest for the analysis, value data allowed the calculation of implied per-unit costs for various trades which were, in turn, used in the validation of global trade prices (discussed below).

Production and Consumption

Domestic supply, demand and processing capacity data came from FAOSTAT and were validated with USDA PS&D data. FAOSTAT data is reported on a calendar year basis and was used to indicate each country's excess supply and demand conditions. The composition of domestic demand (feed, food, industrial demand) was used in applying and weighting the appropriate elasticities to the trade model. Data on soybean processing yields was taken from the USDA PS&D database.

Demand and Supply Elasticities

Demand and supply elasticities were obtained from the CAPRI model to ensure continuity in the analyses performed in this report (see Chapter 6). Where data was unavailable, comparable elasticities were taken from FAPRI and WATSIM [32] .

---

[32] FAPRI refers to the data and modelling system of the Food and Agricultural Policy Research Institute, a collaborative research program of the University of Missouri and Iowa State University. WATSIM refers to the World Agricultural Trade Simulation System, the international trade modelling system of the Institute for Agricultural Policy at Bonn University.

Processing Costs

Soybean processing costs for each country were calculated using a representative soybean crushing facility budgeting framework. Using data from soybean processing in the USA, the EU and Argentina, budgets were constructed for representative facilities of various scales calibrated on known processing costs. The budgeting approach allows operating costs to be broken down by input category (e.g. capital depreciation, wages, use of natural gas, electricity, etc.). Accordingly, constructed processing costs for each individual country reflected the country's average facility size (and relevant economies of scale) and its unique input price vector. Data on each country's average facility size was collected from industry associations, industry reports, and USDA Attaché Reports. Annual natural gas and energy costs were obtained from the USA Department of Energy (DOE) and labour costs from the USA Department of Labor. The resulting estimates were validated and adjusted by industry experts to ensure accuracy and representativeness.

Freight Rates

Freight rates for all possible routes implied in the constructed 38x38 trade matrix used in the analysis were estimated through regression analysis. Actual freight rates reported for soybean, maize and other heavy grain trades over the 1999-2005 period were obtained from Maritime Research. These rates were regressed against the distance covered in each individual trade as well as against selected indexes of bunker and fixtures for panamax and handy size vessels typically used in dry bulk commodity trade. The regression equation was then used to estimate freight rates for all routes and years in the analysis.

Prices

Cash port prices reported by USA, Brazil, Argentina and the EU for the dominant trading ports were the basis of the global trade prices used in the model. Using each country's share of trade with these four countries an average free on board FOB price – the typically reported port price – was constructed for the port of origin. A per-unit weighted average of transportation cost and tariff was added to the FOB price to derive a combined cost, insurance and freight (CIF) price for each importer. These prices were validated by the implied per-unit import costs calculated from GTIS trade data to ensure consistency.

Tariffs

Annual import tariff data was collected from the WTO tariff database using the country's average applied tariff. This data was validated with tariff rates maintained by FAPRI. All export tariffs used were from FAPRI. Tariffs were calculated for country aggregates by weighting the volume of imports (or exports) and average tariff paid for each country.

5.1.2 Baseline development and model validation

The Takayama-Judge (T-J) spatial equilibrium model developed here (described in Takayama and Judge, 1971) is a simplified representation of world trade in maize, as well as in soybeans and processed products (soymeal and soy oil). The model is not a forecasting tool and should not be understood as such. Still, it must effectively represent the direction and magnitude of changes that might occur in response to a given intervention. In this context, an effective representation of observed supply, demand and trade by the model for the countries of interest is important. Hence, the model must be validated for its effectiveness to approximate observed demand, supply and trade conditions in any particular year.

Both the maize and the soybean complex models were calibrated with 2005 calendar year data to ensure consistency with the current CAPRI baseline. Solving the model provides estimates of supply and demand as well as imports and exports for all 38 countries/country groups in the analysis. These baseline estimates can be compared with observed data in order to evaluate the adequacy of the empirical model. Deviations of model-derived baseline estimates from actual demand and supply figures for maize, soybeans, soymeal and soy oil and for all countries. Such deviations – expressed as (baseline-actual)/actual – ranged from -22.8% to 14.8% in the case of maize and from -33.2% to 13.5% in the case of the soybean complex. Most observed deviations were much smaller than the extreme values and the relevant deviations for the world market were 1.7% (maize supply), 2.3% (maize demand), -1.0% (soybean supply), -10.2% (soy oil demand) and -5.3% (soymeal demand). Similarly, calculated trade flows for all large importers and exporters closely matched observed trade flows. Small volume trades were not represented as effectively, which is typical in spatial equilibrium models using annual data as such trades represent opportunistic transactions within a year and hence difficult to represent through annual averages. In all, the baseline model was considered effective.

5.2 Scenario analysis

With an effective baseline in hand, the impact of potential restrictions on the exports of selected countries to the EU could be examined through scenario analysis as outlined in the modelling section. A number of scenarios were considered where restrictions were placed on the exports of (a) a single key producing country (USA); (b) a group of three producing countries (USA / Argentina / Brazil); and (d) all main exporters from North and South America (USA / Argentina / Brazil / Paraguay / Uruguay / Bolivia / Canada). The results of a few representative scenarios are presented and discussed below.[33]

5.2.1 Restrictions on maize trade

EU restricts imports from the USA

In recent years, the USA has exported only small amounts of maize to the EU. As a result, EU restrictions on maize imports from the USA have practically no impact on EU supplies and prices. Due to the limited interest of this scenario, detailed analytical results are not presented here.

---

[33] The scenarios presented here reflect (a) a supply disruption of imports from the USA, (b) supply disruptions of imports from the USA, Argentina and Brazil and (c) supply disruptions of all North and South America significant exporters. These three scenarios are consistent with the “GREEN” / “BLUE”, “ORANGE” and “RED” scenarios discussed in Chapter 4 of this report.

EU restricts maize imports from the USA, Argentina and Brazil

The impact of trade restrictions imposed on maize imports from the USA, Argentina and Brazil is more meaningful. Table 5.3 presents the changes in the trade flows experienced in the world maize market because of the import restrictions. These are expressed as differences from the trade flows in the baseline, which represents normal market conditions. Table 5.4 reports the shifts in the demand and supply conditions in each country as well as the relevant changes in prices caused by the trade restrictions.

From Table 5.3 it can be seen that the restrictions imposed on the three maize exporters removed roughly 1.8 million t from the EU market (1.65 mln t normally imported from Argentina, 120,000 t from Brazil and 50,000 t from the USA). The restrictions caused trade to be reshuffled. Argentina shifted lost exports from the EU to Japan (2.687 mln t) displacing 2.674 mln t of USA maize exports. Some of the USA maize exports, in turn, were shifted to other importers (Canada, Venezuela, Central America) while 1.396 mln t was retained in the USA market.

The reduction in imports and available maize supplies caused EU prices to increase by 4.7% (Table 5.4). This price increase induced EU maize supplies to increase by 906,000 t (1.8%) and EU demand to decrease by 914 ‘000 t (1.7%). Hence, while a total of 1.82 mln t of imports were removed from the EU market due to the restrictions, the net reduction in the EU maize supplies was 914,000 t.

Due to the import restrictions and the associated shifts in trade, prices increased by 4-5 per cent in nearby maize producing regions (central and eastern Europe as well as northern Africa) while maize prices declined by 1-2 per cent in Argentina and the USA, and the maize price in Brazil remained largely unchanged.

It is noted that 2005 was a year of limited maize imports in the EU and hence the modest supply and price impacts are expected. The consequences from import restrictions could be more significant in years when the EU demand for maize imports is larger. To examine such a possibility we recalibrated the model using data from 2007 – a year during which the EU imported larger than average amounts of maize.[34] The results from the scenario analysis when restrictions were once again imposed on imports from the three main maize exporters are presented in Tables 5.5 and 5.6.

Almost 11.5 mln t of maize imports were prevented from the import restrictions during this year (2.8 mln t from Argentina and over 8.5 mln t from Brazil) a large part of which was made up through increased supply in the EU as well as reduction in EU maize exports to other countries. The overall price impact on the EU maize market was more significant under such circumstances and maize prices increased by 23%.

---

[34] From 2005 to 2009, the EU-27 imported varying amounts of maize. Specifically, total imports were 2.88 mln t in 2005; 4.1 mln t in 2006; 10.8 mln t in 2007; 9.68 mln t in 2008 and 2.73 mln t in 2009. Hence, EU imports in 2005 were below normal and 2007 imports were above normal. Modelling the price and supply impacts from trade disruptions during these two years is therefore expected to provide a relevant range.

Table 5.3: Estimated changes in trade flows, supply and demand for selected countries in response to EU import restrictions on Argentina, Brazil and USA maize (expressed as differences from 2005 baseline in thousand metric tons (‘000 t))

	EU27	BRAZIL	ARG	USA	CHN	CAN	BUR	WBA	REU	UKR	EGY	LDC	AFR	C&P	MIDE	ROW	TOTAL DEMAND
EU27	906	-120	-1650	-50	0	0	0	0	0	0	0	0	0	0	0	0	-914
BRAZIL	0	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	111
ARG	0	0	150	0	0	0	0	0	0	0	0	0	0	0	0	0	150
USA	0	0	0	1396	0	0	0	0	0	0	0	0	0	0	0	0	1396
CHN	0	0	0	0	241	0	0	0	0	0	0	0	0	0	0	0	241
PAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAN	0	0	0	45	0	-21	0	0	0	0	0	0	0	0	0	0	24
MEX	0	0	0	0	78	0	0	0	0	0	0	0	0	0	0	0	45
BUR	0	0	-1415	0	0	0	1033	0	0	0	0	0	0	0	0	0	-382
WBA	0	0	0	0	0	0	0	-254	0	0	0	0	0	0	0	0	-254
REU	0	0	-10	0	0	0	0	0	3	0	0	0	0	0	0	0	-7
RUB	0	0	0	0	-421	0	0	248	0	0	0	0	0	0	0	0	-109
UKR	0	0	0	0	0	0	0	0	0	-91	0	0	0	0	0	0	-91
CAM	0	0	0	148	0	0	0	0	0	0	0	0	0	0	0	0	87
VEN	0	0	0	84	0	0	0	0	0	0	0	0	0	0	0	0	41
CHL	0	0	63	0	0	0	0	0	0	0	0	0	0	0	0	0	37
URU	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	7
BOL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RSA	0	0	0	0	0	0	0	187	0	0	0	0	0	0	0	0	117
IND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JAP	0	0	2687	-2674	0	0	0	0	0	0	0	0	0	0	0	0	12
TLD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKR	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	4
INDO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MLAY	0	0	-9	0	0	0	0	0	0	0	0	0	0	0	0	0	-9
PHIL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANZ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOR	0	0	-17	0	0	0	0	0	0	0	0	0	0	0	0	0	-16
TUN	0	0	-7	0	0	0	0	0	0	0	0	0	0	0	0	0	-6
ALG	0	0	-18	0	0	0	0	0	0	0	0	0	0	0	0	0	-18
EGY	0	0	0	-248	0	0	0	0	0	0	95	0	0	0	0	0	-153
TUR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ISR	0	0	-13	0	0	0	0	0	0	0	0	0	0	0	0	0	-12
LDC	0	0	0	0	0	0	-839	58	0	191	0	291	0	0	0	0	-300
AFR	0	0	0	0	-324	0	0	-10	0	0	0	0	132	0	0	0	-202
C&P	0	0	0	38	0	0	0	0	0	0	0	0	0	-9	0	0	29
MIDE	0	-97	0	0	0	0	0	0	0	0	0	0	0	0	32	0	-65
ROW	0	0	0	0	82	0	0	0	0	0	0	0	0	0	0	-44	38
TOTAL SUPPLY	906	-106	-222	-1260	-344	-21	194	229	3	100	95	291	132	-9	32	-44	-197

Table 5.4: Differences in maize supply, demand and prices due to EU import restrictions on Argentina, Brazil and the USA (% change relative to 2005 baseline)

Country/Region	Difference in Supply	Difference in Demand	Difference in Price
EU27	1.8%	-1.7%	4.7%
BRZ	-0.3%	0.3%	-0.7%
ARG	-1.0%	3.4%	-4.1%
USA	-0.5%	0.6%	-1.2%
CHN	-0.2%	0.2%	-0.4%
PAR	0.0%	0.0%	0.0%
CAN	-0.2%	0.2%	-0.5%
MEX	-0.2%	0.2%	-0.3%
BUR	1.5%	-3.3%	3.6%
WBA	2.0%	-2.7%	3.7%
REU	1.6%	-1.9%	4.8%
RUB	1.9%	-2.4%	4.0%
UKR	1.4%	-2.1%	3.4%
CAM	-2.3%	1.5%	-5.3%
VEN	-2.0%	1.8%	-4.5%
CHL	-1.8%	1.4%	-4.5%
URU	-2.7%	2.1%	-4.7%
BOL	0.0%	0.0%	0.0%
RSA	-2.2%	1.3%	-5.3%
IND	0.0%	0.0%	0.0%
JAP	-0.2%	0.1%	-0.4%
TLD	0.0%	0.0%	0.0%
SKR	-0.1%	0.0%	-0.4%
INDO	0.0%	0.0%	0.0%
MLAY	0.7%	-0.3%	1.6%
PHIL	0.0%	0.0%	0.0%
ANZ	0.0%	0.0%	0.0%
MOR	0.8%	-0.9%	4.4%
TUN	1.8%	-0.9%	4.1%
ALG	1.8%	-0.9%	4.2%
EGY	1.4%	-1.2%	4.0%
TUR	0.0%	0.0%	0.0%
ISR	2.6%	-0.8%	4.0%
LDC	1.3%	-1.2%	3.0%
AFR	1.1%	-1.6%	3.7%
C&P	-2.1%	1.2%	-4.4%
MIDE	1.6%	-0.8%	3.7%
ROW	-0.2%	0.1%	-0.4%
TOTAL (World)	-0.2%	0.1%	0.5%

Table 5.5: Estimated changes in trade flows, supply and demand for selected countries in response to EU import restrictions on Argentina, Brazil and USA maize (expressed as differences from 2007 baseline in thousand metric tons ('000 t))

	EU27	BRAZIL	ARG	USA	CHN	PAR	CAN	BUR	WBA	REU	UKR	IND	TLD	EGY	LDC	ROW	TOTAL
EU27	5161	-8531	-2800	-100	0	0	0	780	0	0	-100	0	0	0	0	0	-5590
BRAZIL	0	1426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1426
ARG	0	0	119	0	0	0	0	0	0	0	0	0	0	0	0	0	119
USA	0	0	0	5098	0	0	0	0	0	0	0	0	0	0	0	0	5098
CHN	0	604	0	3500	-1420	0	0	0	0	0	0	0	0	0	0	0	2685
PAR	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
CAN	0	0	0	-2396	0	0	1100	0	0	0	0	0	0	0	0	0	-1296
MEX	0	0	0	-4064	0	0	0	0	0	0	0	0	0	0	0	0	-2251
BUR	-685	-121	0	0	0	642	0	-707	19	0	395	0	0	0	0	0	-271
WBA	-130	16	0	0	0	0	0	0	36	0	0	0	0	0	0	0	-78
REU	-240	0	0	0	0	0	0	0	0	14	0	0	174	0	0	0	-51
RUB	594	0	0	0	0	-646	0	0	0	0	0	0	0	0	0	0	-139
UKR	0	0	0	0	0	0	0	0	0	0	-169	0	0	0	0	0	-169
CAM	0	0	0	-442	0	0	0	0	0	0	0	0	0	0	0	0	-260
VEN	0	0	0	-327	0	0	0	0	0	0	0	0	0	0	0	0	-183
CHL	0	0	0	-99	0	0	0	0	0	0	0	0	0	0	0	0	-67
URU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-10
BOL	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	95
RSA	0	0	0	-690	0	0	0	0	0	0	0	0	0	0	0	0	-445
IND	0	0	0	0	0	0	0	0	0	0	0	230	0	0	0	0	230
JAP	0	0	0	-363	0	0	0	0	0	0	0	0	0	0	0	0	-363
TLD	0	699	0	0	0	0	0	0	0	0	0	-307	-274	0	0	0	118
SKR	0	0	0	-119	0	0	0	0	0	0	0	0	0	0	0	0	-116
INDO	0	0	220	-1478	0	0	0	0	0	0	0	0	0	0	0	0	-645
MLAY	0	0	0	-65	0	0	0	0	0	0	0	0	0	0	0	0	-62
PHIL	0	0	801	0	0	0	0	0	0	0	0	-313	0	0	0	0	249
ANZ	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29
MOR	0	0	0	-106	0	0	0	0	0	0	0	0	0	0	0	0	-102
TUN	0	0	0	-26	0	0	0	0	0	0	0	0	0	0	0	0	-26
ALG	0	0	0	-106	0	0	0	0	0	0	0	0	0	0	0	0	-106
EGY	0	0	0	-910	0	0	0	0	0	0	0	0	0	350	0	0	-560
TUR	-130	0	0	-488	0	0	0	0	0	0	0	0	0	0	0	0	-364
ISR	-250	0	0	189	0	0	0	0	0	0	0	0	0	0	0	0	-52
LDC	0	2286	2687	0	-2338	0	0	0	0	0	0	0	0	0	-1297	0	1254
AFR	0	1733	-1203	0	0	0	0	0	0	0	0	0	0	0	0	0	323
C&P	0	0	0	-124	0	0	0	0	0	0	0	0	0	0	0	0	-97
MIDE	0	0	0	-362	0	0	0	0	0	0	0	0	0	0	0	0	-267
ROW	0	0	0	-2102	0	0	0	0	0	0	0	0	0	0	0	1014	-1089
TOTAL	4320	-1763	-155	-5581	-3756	-4	1100	73	56	14	127	-391	-100	350	-1297	1014	-3032

Table 5.6: Differences in maize supply, demand and prices due to EU import restrictions on Argentina, Brazil and the USA (% change relative to 2007 Baseline)

Country/Region	Difference in Supply	Difference in Demand	Difference in Price
EU27	9.5%	-9.9%	23.0%
BRZ	-3.2%	3.6%	-7.3%
ARG	-0.7%	2.2%	-3.0%
USA	-1.7%	2.2%	-4.6%
CHN	-2.4%	1.8%	-3.9%
PAR	-0.2%	0.4%	-0.8%
CAN	10.4%	-8.6%	23.2%
MEX	8.6%	-7.0%	19.4%
BUR	1.7%	-3.5%	4.0%
WBA	2.3%	-2.8%	4.4%
REU	9.0%	-9.6%	28.8%
RUB	2.3%	-2.7%	4.8%
UKR	1.7%	-2.6%	4.2%
CAM	6.4%	-3.9%	15.3%
VEN	6.4%	-4.7%	17.1%
CHL	3.2%	-2.1%	9.9%
URU	3.6%	-2.1%	7.0%
BOL	-13.2%	11.7%	-29.8%
RSA	7.2%	-4.1%	17.6%
IND	-1.9%	1.2%	-3.1%
JAP	5.7%	-2.1%	15.3%
TLD	-2.9%	3.3%	-8.9%
SKR	4.1%	-1.2%	14.4%
INDO	5.4%	-4.0%	14.9%
MLAY	5.3%	-2.0%	13.9%
PHIL	-3.8%	3.8%	-8.4%
ANZ	-6.7%	6.1%	-13.7%
MOR	4.1%	-4.5%	23.6%
TUN	8.4%	-3.8%	21.2%
ALG	8.9%	-4.1%	22.1%
EGY	6.3%	-4.7%	18.9%
TUR	7.9%	-7.2%	17.3%
ISR	11.7%	-3.7%	18.8%
LDC	-5.4%	4.3%	-14.0%
AFR	-1.7%	2.4%	-5.7%
C&P	7.1%	-3.3%	17.0%
MIDE	6.0%	-2.8%	14.8%
ROW	6.0%	-3.7%	15.3%
TOTAL (World)	-0.8%	0.2%	6.4%

EU restricts maize imports from all main North and South America exporters of maize

The impact of EU restrictions on imports from the USA, Brazil, Argentina, Paraguay, Bolivia, Uruguay and Canada is similar to that in the previous scenario as Paraguay is the only other meaningful exporter of maize to the EU. Imposing restrictions on Paraguay reduces EU maize imports by an additional 510,000 t and causes a 23.6% price increase in the EU maize market. Because of the similarities with the results of the previous scenario, detailed analytical results are not presented here.

5.2.2 Restrictions on soybean trade

Unlike maize, the EU is a dominant importer of soybeans and soymeal in the world market, and as such it is expected that its import restrictions on key producing countries would cause significant adjustments in the global soybean complex. The consequences from EU import restrictions are also expected to be more intricate as shifts in the supply, demand and trade flows in the markets of soybeans, soymeal and soy oil in each country are interdependent.

EU restricts imports from the USA

Restricting EU imports from the USA has the most limited impact of all scenarios involving soybean trade bans presented here, but it is instructive as it illustrates the market adjustments that follow such trade restrictions.[35] In the year represented by the baseline, the USA exported 3.5 million metric tons of soybeans to the EU, only 100 thousand metric tons of soymeal and no soy oil. These amounts are typical of recent USA-EU soybean trade. Exports to the EU from other key producing countries like Argentina and Brazil are also typical of the trade conditions in recent years.

EU import restrictions on USA soybeans kick off multiple shifts in the demand, supply and trade conditions of the soybean, soymeal and soy oil markets, as have been calculated for this study. Banned EU imports from the USA were replaced entirely by imports from Brazil (3.5 mln t). The increase in Brazilian exports to the EU was facilitated by shifts of Brazilian exports away from other markets such as Japan (868,000 t), Turkey (1.034 mln t), Egypt (615,000 t) and others. Displaced exports of soybeans to some of these markets were, in turn, replaced by other suppliers. For instance, Paraguay increased its exports to Turkey (1.034 mln t), Egypt (615,000 t), the Western Balkans (185,000 t), and other locations. Because of such shifts in exports, Paraguay reduced its exports to Argentina by 1.661 mln t.[36] In response, Argentina retained more of its own supply domestically for processing (1.165 mln t) and decreased some of its exports to Japan (565,000 t) and other markets. Reduced Japanese imports from Brazil and Argentina were made up by the USA which shifted some of its displaced EU exports (1.495 mln t). The USA also retained more of its supply in the domestic market (414,000 t) for processing.

Limited changes also occurred in the soymeal and soy oil markets as a result of the EU restrictions on imports from the USA. For instance, declining supplies of soybeans processed

---

[35] Since the model uses annual data, issues of seasonality in supply are abstracted from. These issues are addressed separately elsewhere in the report.

[36] Paraguay normally exports a significant share of its soybeans to nearby Argentina where it is typically processed and re-exported to the world market.

in Argentina caused, in turn, declines in its exports of soymeal to some destinations. Exports of soymeal from Argentina to the Philippines decreased by 416,000 t, a large share of which was made up by the USA. Similarly, reduced soybean amounts processed in Argentina led to reduced exports of soy oil to Brazil (801,000 t) which, in turn, retained more of its soy oil supply domestically (747,000 t) and reduced its exports to China (445,000 t), India (778,000 t) and other destinations.

Because supplies to the EU were unaffected by the trade disruption due to the replacement of USA with Brazilian soybeans, the EU soybean, soymeal and soy oil prices were largely unchanged (soybean prices increased by 0.1% and soymeal prices by 0.3%). The soybean price in Brazil increased by 0.6% and the USA soybean price declined by almost 2.8%, while its price of soymeal increased by 0.3% leading to slightly improved crushing margins. The soybean price changes in the other regions of the world were small to none.

EU restricts imports from Argentina, Brazil and the USA

Imposing restrictions on EU imports from Argentina, Brazil and the USA had a very large impact on the soymeal, soy oil, and soybean markets for all of the major importing and exporting countries. Relevant changes in trade flows for selected countries have been calculated for this study. In the EU soybean market, imports from Brazil were reduced by 11.4 mln t, and imports from the USA were reduced by 3.5 mln t (Argentina only supplied 75,000 t). EU soybean production increased by roughly 440,000 t, and imports from other regions (Ukraine, Eastern Europe, Paraguay, and other countries in South America) increased by roughly 7.1 mln t. The substitution of trade from smaller exporters and the increase in the domestic production were insufficient, however, and total supplies of soybeans to the EU market declined by 7.73 mln t. This amount also corresponded to the reduction in soy crushing activity in the EU.

The large shifts in the trade flows of the EU market induced significant redistribution of trade across all major soybean markets. For instance, Brazil shifted a large share of its banned European exports to China (7.721 mln t) which displaced USA exports in that market (4.876 mln t). In all, China imported a greater amount of soybeans (2.787 mln t). The USA shifted some of its European and Chinese displaced exports to other countries including Japan (1.555 mln t), Mexico (3.5 mln t) and elsewhere. All three banned exporters retained larger amounts in their domestic markets and the total amount of soybeans traded in the world declined by 3.625 mln t as the lost exports to the EU could not be made up with demand from other countries.

Changes in the soymeal EU and world markets were similarly pervasive. EU imports of soymeal from Brazil declined by 10.442 mln t, imports from Argentina by 9.904 mln t and imports from the USA by 100,000 t. In addition, due to the lower processing activity in the EU, domestic supplies of soymeal declined by 4.895 mln t. A portion of the lost imports and domestic supplies was made up by exports from India (4 mln t) and other smaller exporters such as Canada (400,000 t), Paraguay (431,000 t) Bolivia (980,000 t) and others. In total, the EU supplies of soymeal declined by almost 19 million metric tons and world trade of soymeal by 2.958 mln t. Changes in the world soy oil market are more muted due to its more limited size.

The impacts on the EU soybean, soymeal and soy oil prices were even more pervasive. The EU soybean price increased by roughly 220%, while the price of soymeal increased by 211% and the price of soy oil increased by 202%. As a result, crushing margins in the EU soy processing sector worsened. Prices for all major exporters declined within a 7-53% range.

EU restricts soy imports from all major suppliers in the Americas (Argentina, Brazil, and the USA plus Paraguay, Canada, Uruguay, and Bolivia)

When restrictions are imposed on all major exporters of soybeans and processed products in North and South America, there is no feasible spatial equilibrium solution in the world market. In order to obtain a feasible solution we imposed several additional restrictions on the model. First, we allowed demand for soybean and soymeal in the EU to decrease by discrete amounts. This would correspond to significant and immediate substitution of soymeal protein with alternative feedstuffs or, more likely, a sizeable culling of EU livestock that would cause a significant immediate decline in demand for soybeans and soymeal.

Second, we forced minor suppliers to send all or nearly all of their aggregate supply to the EU in order to form a feasible solution to the spatial trade problem. For soybeans, these countries include Bulgaria, Romania, Russia, Belorussia, Ukraine, and the Western Balkans, and the same countries plus the rest of Europe also exported all of their soymeal supply to the EU. These complemented EU imports of soybeans from China (3.1 million metric tons, which is roughly 20 per cent of Chinese aggregate supply) and imports of soymeal from India (4.1 million metric tons, which is roughly two-thirds of aggregate meal supply in India), which occurred without any intervention.

Third, we relaxed the no-arbitrage constraints[37] in order to allow the product prices to adjust by enough to generate a feasible solution. Under scenarios that only involve one to three banned countries, we follow the standard approach and only remove the no-arbitrage constraints between the banned parties (e.g., the EU and the USA). Accordingly, the remaining no-arbitrage constraints link the prices between the banned markets and all third parties, the prices between the EU and all third parties, and the prices among all of the third parties. Thus, the prices in the EU were indirectly linked to the prices in the banned markets through the price relationships with the third parties. However, as noted above, the scenario that involves trade restrictions on all seven of the major suppliers in the Americas required an unusually large displacement of exchanged products in order to solve the trade problem, and the full set of no-arbitrage conditions will not hold if some countries are exporting all available supply. To represent this unusual situation, we remove the no-arbitrage links between the EU and all other countries and between the banned countries and all other countries. The price relationships among the countries in the banned group and among the third parties were separately maintained.

Despite all these adjustments, prices increases in the EU were still larger than those observed in previous scenarios (of different levels depending on the amount of demand reduction allowed in the EU). We therefore conclude that the displacement of supplies and price impacts in the EU from restrictions on the imports of all major suppliers in the Americas

---

[37] The no-arbitrage constraints imply that the absolute price differences between any two countries/regions are less than or equal to the relevant transportation and per-unit import and export tariff rates (see discussion of arbitrage constraints in 11.3.2)

would be significantly higher than those observed in the previous scenarios. Their levels, however, would depend on the immediate adjustments that might be possible on the demand side of the EU market.

5.2.3 Limits of the analysis

The spatial equilibrium analysis presented here should be viewed as short/intermediate run analysis. Long run analysis of potential price and supply impacts from trade restrictions allowing for demand and supply substitution across alternative feedstuffs and other potential market adjustments is performed through the CAPRI model and presented in Chapter 6. Certain limits of the analysis stemming from the structure of the spatial equilibrium models must also be recognized.

The Takayama-Judge spatial equilibrium models used to represent trade flows in the international maize and soy product markets are based on some specific assumptions about the behavioural structure of these markets. One assumption is that the aggregate supply and demand functions in each sector are linear and may be parameterized from observed information about country-specific prices, quantities, and elasticities. The linear character of the supply and demand functions may represent more effectively the behaviour of importing and exporting countries under relatively small deviations from the observed market conditions instead of large shifts. In particular, the slopes of these functions are derived from fixed estimates of the supply and demand elasticities, which are generally appropriate under typical price and quantity conditions but may need to change for drastically different price-quantity regimes. Under extreme shifts in the market conditions, like the large-scale trade disruptions observed in the global soybean complex under some scenarios of asynchronicity, the model representations may provide only linear approximations to the potential changes.

Another assumption built in the model specification is that stockholding or storage activities are largely captured by the domestic demand for the unprocessed products (i.e., maize and soybeans). Under typical supply and demand circumstances this assumption is appropriate. However, domestic maize or soybean stocks may initially surge in exporting regions that are subject to trade restrictions, stocks in importing regions that impose the restrictions may be temporarily reduced, and third parties may increase or decrease stockholding depending on the impact of the restrictions on their domestic prices. Thus, explicit allowances for stocks could partially mitigate the short run price effects of a trade disruption, especially in exporting countries.

Finally, it is important to note that the supply and demand functions remain static and do not shift in response to the impacts of the trade restrictions. For example, soybean processing costs are assumed to be constant per-unit values, which may be appropriate within the typical range of processing activity. However, we may expect these costs to increase as the quantity of soybeans processed in a country declines due to trade disruptions.

6 Impacts of feed supply disruption in EU livestock sector and related industries

Ignacio Pérez Domínguez, Roel Jongeneel

6.1 Introduction

This chapter discusses the results of the simulated feedstuff supply disruptions on the EU livestock sector.

6.1.1 Summary of simulated scenarios and imposed supply disruptions

Table 6.1 provides a short overview of the scenarios of feedstuff supply shocks that might affect the EU livestock sector, and provides additional information on the way the import restrictions associated with specific supply disruptions are considered. (For a detailed description of the scenarios see Chapter 4.)

Table 6.1: Scenario description and the imposed supply shocks / price increase in the short term and medium to long term

Short term shock (2012)	GREEN soy	ORANGE soy	ORANGE maize
Brief description	Temporary loss of USA supplies during 3 months	Structural loss of USA, Brazilian and Argentinean supplies	Structural loss of all key suppliers
Trade supply shock (mln t)			
Soybeans or maize		-14.2	*)
Soymeal	-5.8	-21.3	
Long term shock (2020)	BLUE soy	RED soy	RED maize
Brief description	Structural loss of USA supplies	Structural loss of most North and South American supplies, except Canada	Structural loss of all suppliers
Trade supply shock (mln t)			
Soybeans or maize	-0.1	-15.8	-1.6
Soymeal	-3.5	-23.3	

*) Two variants were considered. First, the imports from both Americas were blocked, which had only a marginal impact on maize prices. Second, a shock was generated equivalent to a 10% import price of maize increase (see for further motivation the main text).

Table 6.1 summarizes the scenarios and the trade shocks associated with each of them (more details are found in the tables that follow). Although we strived for similarity between the scenarios as simulated in the T-J trade modelling analysis (see Chapter 5) and the impact analysis of supply disruptions on the EU livestock sector in this chapter, the reported impacts of disrupted feedstuff imports might be a bit different as compared to Chapter 5. The main reason is that the exact number or amount of imported feedstuffs that has to be taken into account depends on the specific reference year (which was different for the different models)[38].

As already became clear in Chapter 5, imports of maize of the EU-27 are nowadays rather limited (that was the reason why in the simulated maize supply disruption two different base years were used (2005 and 2007), with maize imports being relatively small in 2005 and maize imports being more significant in 2007. Also the simulated short run impacts for both base years were different (+5% and +23% respectively). Note that the results of the short run price impacts obtained from the T-J modelling analysis take into account reallocation of trade (substitution of trade partners by the EU) but ignore adjustments in the EU (*inter alia* change in the EU's domestic production, change of intra-EU trade patterns, substitution between feed ingredients and changes in demand for livestock products by consumers).

Since in the projected 2012 baseline maize imports are again rather limited, imposing a supply disruption would hardly show any intermediate to long run impacts (even significantly less than the 5% maize price increase that has been obtained from the short run T-J impact analysis). In order to have more insight in what a more substantial maize price increase would imply for the supply chain, as an alternative, an artificial supply disruption equivalent to a 10 per cent increase in the EU's maize price was therefore analysed[39]. Note that this is about half of the price increase found in the short run impact analysis, for a reference year (2007) in which the EU-27 imported a significant (although still limited) amount of maize. As is shown in Table 6.2 below, the additional adjustments taken into account for the intermediate to long run equilibrium show a tendency of the initial projected short run price increase to be approximately halved.

Note that in contrast with the T-J trade impact modelling outcome, the EU livestock sector intermediate to long run impact analysis made in this chapter is able to take into account the full potential of import replacement by increased EU home production of soybeans or maize,

---

[38] The trade modelling analysis was based on reference years for which actual trade data were existent (2005 and 2007). The reason was that the trade model need a very detailed input of trade data. Moreover, the model was not only calibrated to these data, but also checked against these data (in particular with respect to the precision with which it could approximate the about 1400 bilateral trade flows per product. This was felt necessary for checking the robustness of the analysis, but also so data demanding that it was infeasible to run this model for projected future reference years (such as 2012 or 2020). Nevertheless, since the modelling tools used, both have a comparative static character, it are the relative price and volume changes, which are felt to be most important (i.e. more important than the exact base year choice) and still indicative for what happens in terms of short run and intermediate to long run impacts. The reason why it was still chosen to use for the EU impact analysis reference years 2012 (supply disruptions taking place in short run) and 2020 (supply disruptions taking place in long run) was to take into account, on the one hand, the dynamic shifts in trade patterns (e.g. the rapidly increasing soybean imports of China over time, etc.) and, on the other hand, the relevant changes in EU agriculture and trade policies (e.g. the planned abolition of the milk quota in 2015, the EU's bio fuel policy, etc.).

[39] As explained in the main text, the simulated 10 per cent maize prize increase is not likely to be a realistic outcome for a long run equilibrium under the assumed (baseline) market conditions, although in the short run such price increases (and even higher ones) will be possible (see the reported price increases for the short run trade impact analysis). Still assuming such a high long run equilibrium price allowed us to assess what the impact would be of such a price change throughout the supply chain.

the full impact of feed ingredient substitution by either the compound feed industry and/or by farmers (rebalancing feeding from roughage and compound feeds), and the potential balancing adjustments in the final demand for livestock products. For that reason the T-J impact analysis, which implies an assumed limited flexibility of the supply chain to adjust, reflects a short run equilibrium. The short run situation does not reflect a long run equilibrium situation, since the observed prices and volumes are not yet stable and further adjustments are still taking place along the supply chain. This chapter takes into account a full utilization of feed substitution and land use reallocation options in the crop-feed-livestock supply chain. This explains why the projected price increases for the agricultural commodities implicated in one way or another by the response to a supply disruption are lower in the long run than in the short run.

Figure 6.1 further illustrates the short run and intermediate to long run impacts in a stylized way. The bold line shows a possible and typical evolution of the price of a crop facing a structural or permanent supply disruption. (Note that Figure 6.1 does not discriminate with respect to the moment the supply disruption take place, which could be either in the short term (e.g. 2012) or the long term (e.g. 2020), but rather focuses on short run, intermediate run and long run impacts.) As can be seen from the graph, immediately after the shock the price starts to strongly increase until it reaches its peak, after which the price starts a gradual decline as a result of all kinds of adjustments along the supply chain. As is typical for a case with a structural supply disruption, the long run equilibrium price stabilizes at a level which is higher than the initial price (before the shock occurred). (Permanent shocks in general have permanent consequences, whereas temporary shocks will only have temporary consequences).

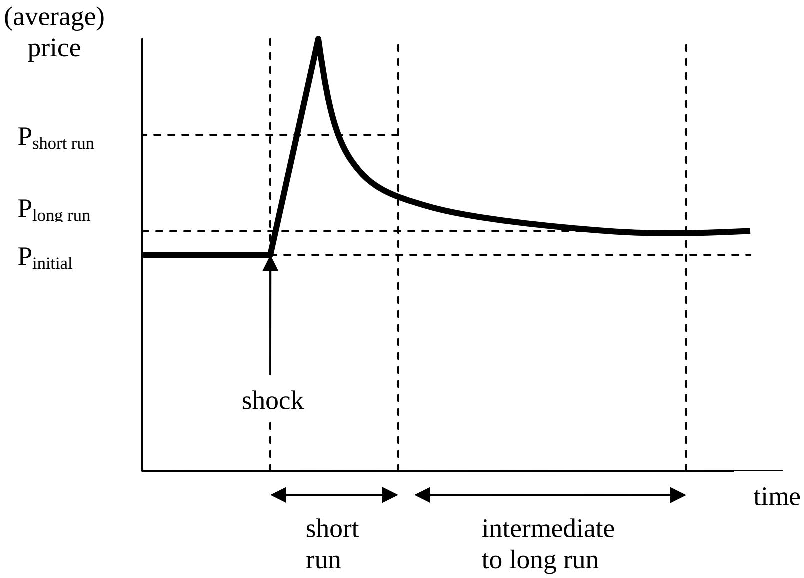

Figure 6.1: A stylized presentation of the impact of a structural supply disruption on the evolution of feedstuff price in the short and intermediate to long run

6.1.2 Overview of estimated short run and long run price impacts for the simulated scenarios

Table 6.2 provides an overview of the estimated short run and long run projected price changes for the simulated scenarios. Given the host of complexities characterizing the soy and maize component of livestock feed supply chains, these estimates – although based on an extensive modelling analysis aimed at taking all relevant factors in a systematic way into account – should be taken as indicative. For example, the supply disruptions are simulated under 'normal' conditions, such as normal weather conditions, etc. If, for example, a supply disruption would occur in combination with a bad harvest year, then the price impacts could be worse (higher price increases). In the GREEN soy scenario, which particularly focuses on a supply disruption with a duration of 4 months and also the moment that such a within-year supply disruption would occur (seasonality), an assessment is made to account for the potential impact of weather or bad harvest conditions (approximated by the level of stocks). Such specific weather or harvest conditions will in particularly affect the short run impacts, but are less relevant for the long run impact analysis, as for the latter it might be assumed that weather conditions and the like will be 'normal' or average. Note that Table 6.2 shows that, depending on the type of market disruption, the impact on the soy (protein) feed price and maize price could be substantial. As Table 6.1 already indicated, not only in terms of prices but also with respect to import quantities, the EU could have to cope with a shortage of soybeans and soymeal on a massive scale (cf. ORANGE soy and RED soy scenarios)

Table 6.2: Estimated indicative (border) price impacts (in % price change) on soybean, soymeal and maize prices for short run and intermediate run for analysed scenarios *)

Short term supply disruption (2012)		GREEN soy	ORANGE soy	ORANGE maize
Short run impact	Soybeans or maize	5-20	220	4 - 24
	Soymeal	3.5 - 20	211	
Long run impact	Soybeans or maize	0 **)	83	0 – 10 ***)
	Soymeal	0 **)	105	
Long term supply disruption (2020)		BLUE soy	RED soy	RED maize
Short run impact	Soybeans or maize	0.1	n.a. ****)	not calculated *****)
	Soymeal	0.1	n.a. ****)	
Long run impact	Soybeans or maize	-0.1	138	7.5
	Soymeal	-3.5	107	

*) Best estimates based on calculations and modelling analysis

**) The GREEN scenario represents a non-structural of non-permanent supply disruption (US soybean imports blocked for a 4 month period), which will have non-permanent consequences (e.g. long run impact on prices is zero since the economy would after the shock return to its original equilibrium).

***) When blocking both the America's a marginal price increase close to zero was found. When also the Western Balkans are blocked the maize price increased but not beyond 5 per cent. As a more extreme case then

an exogenous maize price increase of 10% was imposed (which is about half of the 24% price increase found for the short run trade analysis impact assessment (see further motivation in main text).
****) No equilibrium solution could be found for the short run, without adapting the trade impact analysis model in an ad hoc way. However, from comparing the RED soy with the ORANGE soy scenario (where the first is more restrictive with respect to the amount of EU soy imports blocked than the latter), it could be argued that the price increases for soybeans and soymeal should be over 220 and 211 per cent respectively.
*****) Not calculated but impacts would likely have been in a similar range as those found for the ORANGE maize scenario.

The following structure is used with regard to the discussion of the impacts of the scenarios. First the trade shocks imposed on the model and associated with the various scenarios are discussed (including restrictions on both the imports on soybeans as well as soymeal into the EU). Subsequently the impact of this on the trade balance is discussed, which includes the endogenous response of the model to the shock. Not only are adjustments in the trade of soybean products looked at, but also the induced changes in related feedstuff markets are taken into account. This discussion on changes in volumes imported (with a focus on changes in net trade) is followed by a discussion on changes in the price structure, with a focus on the soybean and soymeal market.

The changes in the trade volumes and in prices of feed products will also trigger adjustments within EU agriculture, both in the crop sector as well as in the livestock sector. After considering the changes in the trade of soy products and the other main feed ingredients, then the change in land use and EU home-based production of feeds is analysed. After all impacts on the feed market are analysed, their impact on the downstream livestock sector is assessed. Depending on the assumed relevance, different levels of aggregation are chosen. Some impacts are assessed at EU-27 level, others at Member State level (e.g. trade in soybean products), and others at regional level (e.g. changes in EU livestock production).

Scenario results are discussed in terms of how their outcomes deviate from the baseline (either in percentage changes or in absolute changes). For the long run analysis (BLUE and RED), the 2020 situation is the reference. For the short run impact analysis (GREEN and ORANGE) ideally 2012 should be used as a baseline. For the GREEN scenario, it was decided to avoid an extensive base year comparison at all, because for a short run supply disruption (without structural consequences) applying an extensive modelling analysis was found not useful. As has been further discussed in Chapter 4, for the GREEN scenario a projection was made using 2010/11 trade data, accompanied by an analysis of past incidents in the period 2003-2010. For the ORANGE scenario a full quantitative analysis was done, with 2012 chosen as a reference year.

The sections below provide a further discussion of the trade shocks and their impacts on the provision of the EU with soybeans and soymeal (e.g. including responses of other countries to the imposed trade restrictions). The main focus will be on the impacts the simulated supply disruptions have at the livestock sector and consumers.

6.1.3 Assessing impacts on the livestock sector

For assessing the impacts (volumes, prices) that the simulated feedstuff supply disruptions will have on the livestock sector, a step-wise approach is applied following the structure of costs and revenues at different stages of the supply chain. As an example, a price increase of soymeal will affect the costs of the feed bill for dairy farmers, with the specific effect depending on how crucial the role of soymeal is in the specific animal feeds. Different livestock sectors are relying to different degrees on feed input (other than roughage). This implies that a certain percentage feed cost increase has a different impact on the total costs of production, and thus a different impact on the competitiveness of different livestock sectors.

6.1.3.1 Competitiveness

As regards assessing the competitiveness of the livestock sectors, two other indicators are considered alongside the impact on costs of production. First, there is the information on a sector's profitability (measured in terms of gross margin) as an important indicator of its viability. Second, competitiveness could be analysed in terms of how good a sector succeeds in preserving or even increasing its market share. Market share indicators can be calculated in several ways (e.g. within sectors and over countries; over sectors within a country, etc.)[40]. In the following a selection of relevant indicators will be mentioned. Given the asymmetric impact of market disruptions (leading to price increases within the EU and on the average a relative price decline elsewhere in the world), this poses clearly a threat to the EU's external competitiveness in livestock products. The extent to which this materializes, however, will strongly depend to the degree of protection offered to these sectors, which will affect the potential inflow of livestock products from outside the EU. As became clear from the baseline analysis presented in other studies (e.g. Nowicki et al., 2009), there is a significant degree of protection inherent in the current policies.

6.1.3.2 A step-wise approach for the livestock impact assessment

As regards the 'mechanics' of the transmission of the impact of a price increase in maize or soy feed ingredients throughout the livestock product supply chains, and understanding the relative magnitude of impacts at different stages of the chain, Figure 2.1 (Chapter 2) might be helpful. As it suggests, the impact on feed costs of a feed ingredient price increase is related to the impact on total costs. Total costs are in turn part of the total output value (see Figure 6.2 for the illustrative set-up). The difference between total revenue and total costs determines the profitability of an activity (e.g. its gross margin). By following these steps, the impact of a market disruption in soy and maize markets is linked to the impact it has on the livestock sector. Even if no adjustment would take place, already by linking cost increases in feed up with the shares of feed costs is total costs, and total costs in final product revenue of specific livestock sectors, one insight gained is that in percentage terms the impact will be dampened the more downstream you come in the supply chain. The basic reason for this is that although feed costs are important and surely non-negligible, they comprise only part of

---

[40] Note that CAPRI's strength is the comparison of equilibrium states. This also impacts the way it addresses competitiveness. In the short run the relative price structure might be quite different from the one in the long run. Moreover, relative prices might change significantly over time during the transition process. This will also have its (short run) impacts on competitiveness.

the final product value (measured at the farm gate, and even more so when measured at retail level). But with the impacts at the livestock product level (measured in percentage changes) being ‘scaled down’ when moving along the value chain, it also explains why the responses to the livestock markets are likely to be less pronounced relative to the impacts found in the soybean and soymeal markets.

It should be noted that, in reality, when a shock occurs the shares of costs and gross margin will generally not remain constant, but adjust due to changing economic conditions and market responses. For example, when competitive pressure precludes a sector from passing on the input price increase to the final product price, the (profit) margin might adjust, and adjustments might take place as well in other input or factor markets (e.g. other feed ingredient markets, land market, etc.). This is illustrated in Figure 6.2 by the arrows which indicate increases in costs. Note that this can end up in two ways: costs are passed on to the consumer, and as a result of the feed cost increase the consumer prices for livestock products will increase. But this might only be partly the case. Another possibility is that the livestock farmer’s gross margin is acting as a buffer and becomes squeezed. Of course both impacts may also occur at the same time. Note that the impact of an *x*-per cent increase in a feed ingredient input is likely to be associated with an output price increase of livestock products which is much less than *x*-per cent. As an example, when the soymeal price increases by 50% and the share of soy in the value of the livestock products is 20%, the livestock product price will increase by only 10% *ceteris paribus*. In case cost increases cannot or can only partly be passed on to the consumer, probably also profits, gross margin or farm income will have to buffer part of the feed cost increase. Note that even though the impact on the final product value might be small, this does not mean that the impact on ‘profits’ is also likely to be small. In general it holds that the smaller the ‘profit’ margin, the more pronounced the negative effects from cost increases will be. As Figure 6.2 suggests, particularly when the gross margin of a livestock production activity is a small fraction of total revenue (or equivalently there is a small difference between revenue and costs), it can be heavily impacted when it has to contribute to buffer the input price increase (i.e. an input price increase with *x*-per cent can easily imply a reduction in gross margin (or profits), which is much larger than *x* per cent. The strength of the CAPRI livestock impact analysis tool is that it takes all these impacts into account in a systematic way, while preserving consistency[41]. However, using actual empirical farm accountancy data, the impacts on gross margin will be further investigated with respect to their impact on farm viability or competitiveness.

---

[41] In this regard it is important that input and output responses are related to each other in a consistent way (to be ensured by appropriately modelling the production technology). For example, models based on independently calibrated input demand and output supply curves cannot in general ensure such consistency and may lead astray, in particular in case of extreme shocks. As an example, the Burger et al. (in preparation) study, which was referred to earlier in this study when elaborating on potential very short run impacts of market disruptions, does not guarantee at all places this kind of consistency.

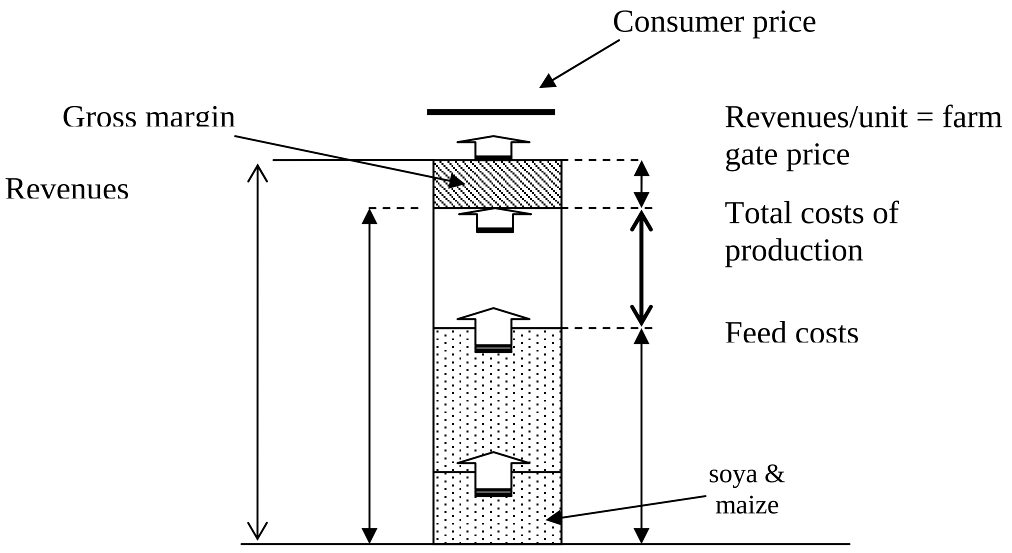

Figure 6.2: Cost and revenues along the value chain of livestock products

The final impact of the cost increase of a supply disruption which needs to be further distinguished is the impact on the consumer. This will be evaluated by the change in consumer welfare. Also other welfare effects will be considered, with the aim to get an estimate of the impacts on the processing industries.

6.2 Short term scenarios (horizon 2012)

6.2.1 Trade effects on soy products

GREEN soy scenario

In the GREEN scenario, which has a stylized character, it is assumed that an LLP incident takes place less than once a year, just like in recent years with some incidents of commingling. Moreover, it is assumed that one supplier, notably the USA, cannot deliver temporarily to the EU market. As a result of this non-permanent shock, prices of soy on the world market will peak after such an incident (partly due to speculation). Because these are only isolated incidents, no structural change is assumed to take place in producing countries nor in the importing countries (non-permanent shocks have non-permanent impacts). Substitution possibilities are expected to be relatively limited (see Chapter 4 for further details). Within the GREEN scenario a distinction is made with respect to: a) the moment in the year the incident takes place (USA is in season or out of season) and b) whether stocks in the southern hemisphere in the period considered are high or low (as to reflect good or bad weather conditions during the relevant crop seasons).

Table 6.3: Impacts of GREEN scenario (3 month supply disruption in US) on feed bill for EU-27 in million euro, taking into account seasonality and weather conditions

	USA out of season			USA in season		
	% price change	high stocks	low stocks	% price change	high stocks	low stocks
	Soya bean and meal markets					
soybeans	5	48.8	48.8	25.0	97.5	243.8
soymeal	3.5	32.3	45.3	20.0	64.7	258.8
	Other feed ingredient markets					
cereals	0			10.0	76.3	305.3
other oilseed meals	0			15.0	4.5	33.8
other feeds	0			10.0	11.3	45.0
by-product, additives etc.	0			2.5	8.0	19.9
Total costs mill.€		81.1	94.0		262.2	906.5

As Table 6.3 shows, the estimated costs in the feed bill for the EU-27 vary between €81 million till €906 million (see also Chapter 4 for further details). Note that the price increases used in the simulations for the various scenarios are best-estimates, taking into account an analysis based on past incidents.

ORANGE soy scenario

In the ORANGE soy scenario, a large shock on soybeans and soymeal imports of about -14.2 and -21.3 million metric tons respectively is simulated in the short term, under the hypothesis that basically most traditional exporters to the EU (e.g. USA, Brazil, and Argentina) are affected by asynchronicity in EU approval of new GM events. It is expected *a priori* that this considerable trade disruption permits non-traditional exporters to gain quota on the EU market. Moreover, segregation or safeguarding of regional production flows is allowed, so that the supply from other regional soy markets (in South or North America) is not fully distorted. The EU excess demand for protein is not expected to be fully covered, so that changes in domestic feeding and livestock production mix are expected. As Table 6.4 shows, non-traditional exporters (countries other than USA, Brazil and Argentina) succeed in filling large parts of the deficit created by the simulated market disruption. For soybeans, the assumed supply restriction implies that 14.2 mln t of imports from the main exporters is prevented from entering the EU, but that after rearrangement of trade patterns and supply responses in the rest of the countries, about 90% of this gap is filled by other suppliers. As most of these beans have to be crushed, this implies that the turnover of the EU crushing industry, as measured in volume terms, will be affected, but only to a limited extend. For soymeal, the trade substitution is much lower, with only 13% of the gap recovered. The remainder of the gap has to be closed through substitution by alternative feed ingredients, which might be imported into the EU, or domestically grown (change in EU domestic feed stuff and roughage production).

Table 6.4: Soy trade changes in EU soy imports in ORANGE scenario compared to the short term baseline (2012)

	Baseline (short-term)			Scenario ORANGE (short-term)		
	Soybean [1000 t]	Soy cake [1000 t]	Soy oil [1000 t]	Soybean *[D to REF]*	Soy cake *[D to REF]*	Soy oil *[D to REF]*
Main exporters						
USA	3899	101	1	*-3898*	*-101*	*-1*
Brazil	9931	5614	2	*-9930*	*-5614*	*-2*
Argentina	360	15021	2	*-360*	*-15020*	*-2*
Rest of countries						
Canada	268	7	0	*4352*	*904*	*0*
Paraguay	581	23	0	*5839*	*-13*	*0*
Uruguay	146	2	0	*376*	*42*	*0*
Bolivia	4	4	0	*732*	*497*	*0*
Other countries	45	213	51	1663	2385	34
Total	*15233*	*20984*	*57*	*-1227*	*-16919*	*29*

The estimated associated price increases for soybeans and soymeal are 83% and 105% respectively. These price increases lead to increases in feed costs in EU-27 ranging from 2 to 7 per cent depending on animal type. See the next section for a further discussion of these impacts.

ORANGE maize scenario

As indicated before (and as is also shown in Table 6.5) in the ORANGE maize scenario the imports of Argentina, Brazil and the USA to the EU were prevented from entering the EU. As Table 6.5 shows, the impact on the provision of the EU with maize will only be affected in a very minor way, since the share of the Americas in total EU maize imports is low. Also the border price increase of maize is negligible. As a result all other impacts along the supply chain of this scenario will be minor and not worth discussing in further detail.

As an alternative, in order to get more insight into the potential impacts of a more significant maize price increase, an exogenous world market price of maize increase (10%) has been simulated and its effects have been traced along the supply chain. These impacts will be discussed later. The price increase also translates in a maize price increase for primary producers, which then generates a supply response in the EU. Note that the price increases at the farm gate might differ from the boarder price increases, depending on the net trade position and transportation costs. Table 6.5 provides an overview of the associated maize price increases in EU-27 regions (supply details are provided in section 6.3.3 below). As is shown in Table 1.3 in Chapter 1, Spain and the Netherlands in particular are the Member States that are importing maize from outside of the EU, and these MS might be expected to be the most affected.

Table 6.5: Maize price changes (at farm gate level) for EU Member State implied in EU maize imports in the ORANGE maize scenario

	Reference 2012	ORANGE maize	% change
European Union 27	122.28	130.97	7.1
European Union 15	124.87	132.19	5.9
European Union 10	96.23	105.13	9.2

6.2.1.1 Impacts on the livestock sector

This section considers the impacts of the short term scenarios on the livestock sector. Since it will become clear from the assessment of the long run equilibrium impacts on the soy and maize markets, the long run impacts on feed costs are limited for two out of the three scenarios. For that reason the discussion will focus mainly on the impacts of the ORANGE soy scenario.

GREEN soy scenario

Since there will be no lasting impact of the incidental within-year shock, it makes no sense to analyse its long run impacts on the livestock sector. Since temporary incidents will have non-permanent effects the economy will return to its initial equilibrium. This implies that the long run impacts on the livestock sector will be zero by definition.

ORANGE soy scenario

The estimated associated price increases for soybeans and soymeal are 83% and 105% respectively. Table 6.6 shows the downstream changes in revenues[42] and costs, evaluated per unit of livestock activity (e.g. per cow, per pig). As Table 6.6 shows, the price increases of soybeans and soymeal lead to increases in feed costs in EU-27 ranging from 2 to 7 per cent. In percentage terms the long run impacts to the livestock sector seem to be limited, but Table 6.6 needs careful interpretation. First, note that the feed cost increase is partly passed on to the end users or consumers. This is reflected in the increase in the revenues farmers receive. Behind this increase in revenues are two counteracting factors. On the one hand the price of livestock products increases, due to the increase in costs. On the other hand consumers start to reduce their demand as a response to the price increase. However, it turns out that the net result is positive for the revenue farmers receive. In other words: the impact of the increase in the price farmers get outweighs the impact of the loss in turnover due to the reduction in the volume consumed[43]. From Table 6.6, it can be deduced that often 60 to 90 per cent of the feed cost increase is passed on to consumers. Second, note that also the gross margin plays a role in balancing the impacts of the feed cost increase. Although the reduction in gross margin – as evaluated in percentage terms – is limited, the final impact this will have on a farm's competitiveness needs further reflection. As gross margin still includes fixed costs, the final impact on farm income or profitability may be affected by a multiple of the percentages observed in Table 6.6. For a further assessment see section 6.4.1 below.

---

[42] Revenue refers to the value of the output of a livestock activity (measured on a per unit basis). As an example, the revenue from a dairy cow is composed of the return on the milk this cow produces in one year. Note that this is different than the milk price, but changes in revenue are, of course, related to milk price.

[43] This phenomenon can be related to the so-called elasticity of (derived) consumer demand for livestock products. These are in general inelastic, which implies that in case of a reduction in demand the percentage price increase will be more than proportional as compared to the percentage volume reduction.

Table 6.6: Impact of soybean and soymeal price increases within the ORANGE scenario on the EU-27 livestock sector

	Baseline (short-term)					Scenario ORANGE (short-term)				
	Revenues [€/hd]	Feed costs [€/hd]	Remonte [€/hd]	Other costs [€/hd]	Gross margin [€/hd]	Revenues [€/hd]	Feed costs [€/hd]	Remonte [€/hd]	Other costs [€/hd]	Gross margin [€/hd]
Dairy cows production activityhigh yield	2231	823	173	170	1064	*1%*	*5%*	*-1%*	*0%*	*-1%*
Beef meat production	744	287	299	40	118	*1%*	*3%*	*1%*	*0%*	*-4%*
Pig fattening activity	120	52	22	10	36	*2%*	*5%*	*3%*	*-1%*	*-2%*
Sheep and goats activity for fattening	65	12	18	8	27	*1%*	*7%*	*3%*	*0%*	*-2%*
Poultry fattening activity	2.3	1.3	0.1	0.5	0.4	*1%*	*4%*	*1%*	*0%*	*-4%*
Laying hens production activity	16.1	8.2	0.1	1.8	6.1	*1%*	*2%*	*1%*	*0%*	*1%*

ORANGE maize scenario

As indicated before (and is also seen in Table 6.5) the impact of a supply disruption with regard to EU maize imports is rather limited. Not only is the maize price increase limited, but it also turns out that there is a lot of flexibility to replace the maize in feed rations by other feed ingredients. Moreover, it turns out that the import reduction is partly balanced by two further effects: 1) EU-27 exports of maize to outside the EU countries declines; 2) EU-27's home production of maize increases. Together these adjustments are sufficient to fill the gap, also for Member States that are in the reference year rather reliant on imports of maize from outside the EU. The increase in feed costs in all cases was less than 0.5% and adjustments in other costs, gross margin and revenue were even much lower. Because numbers were small and of negligible order no table on impacts is reported.

6.3 Long term scenarios (horizon 2020)

6.3.1 Changes in trade of soybeans and maize

BLUE soy scenario

In the BLUE scenario a moderate shock on imports of soybeans of about -3.5 mln t is modelled for the year 2020 (long term analysis). This disruption of imports is assumed to be solely concern the USA. Regional soy markets are not heavily distorted, so the other main exporters are expected to cover the induced gap between supply and of demand without major problems. As Table 6.7 shows, in the new market equilibrium the structural loss of the USA as a supplier to the EU is over-compensated by Brazil and other countries. Although in the GREEN scenario (see discussion in Chapter 4) it becomes clear that there are non-negligible short-run impacts, which could in the worst case even lead to additional expenditure on feed of about €900 million, in the longer run such a shock can be fully accommodated by other suppliers. Note that although it is in particular soybeans which are prevented from entering the EU (the US supplies mainly soybeans to the EU), in the final equilibrium EU soybean imports are not lower (but even slightly increased) than in the baseline (see also below for some further discussion on this result).

Table 6.7: Soy trade changes in EU soy imports in BLUE soy scenario compared to the 2020 baseline

	Baseline (2020)			Scenario BLUE (2020)		
	Soybean [1000 t]	Soy cake [1000 t]	Soy oil [1000 t]	Soybean *[D to REF]*	Soy cake *[D to REF]*	Soy oil *[D to REF]*
Main exporters						
USA	3520	138	1	*-3520*	*-138*	*-1*
Rest of countries						
Brazil	11283	5336	1	*3355*	*40*	*0*
Argentina	405	17758	1	*192*	*139*	*0*
Rest of the world	1229	249	60	282	28	1
Total	16436	23481	64	310	68	0

RED soy scenario

In the RED scenario a shock similar to the one in the ORANGE scenario is modelled (-23.3 mln t of soybeans and -16.1 mln t of soymeal in the year 2020). But additionally other soy exporters in the Americas are excluded from the EU market. Segregation is not considered feasible (apart from Canada, a country that is known to have invested a lot in segregation schemes) and all the regional soy pools in South America are excluded from accessing EU markets along with the USA. In this situation, a strong development of EU domestic soy markets and the appearance of non-traditional soy producers in other parts of the world are expected. The adaptation of the EU livestock sector in this situation strongly depends on the substitution possibilities observed (and cross-checked with experts for their feasibility). As Table 6.8 shows, this scenario has radical implications for the EU's provision with soy products. The decline in soybean deliveries coming from the Americas is only to a limited extent compensated by other countries (mainly from Eastern Europe (among them Ukraine), Africa and Asia)[44]. This implies that further adjustments along the supply chain are unavoidable to guarantee that balances close (e.g. changes in EU domestic soy production, changes in EU cereal and protein crop production, changes in roughage production and/or changes in the livestock sector).

Table 6.8: Soy trade changes in EU soy imports in RED soy scenario compared to the 2020 baseline

	Baseline (2020)			Scenario **RED** (2020)		
	Soybean [1000 t]	Soy cake [1000 t]	Soy oil [1000 t]	Soybean *[Δ to REF]*	Soy cake *[Δ to REF]*	Soy oil *[Δ to REF]*
Main exporters						
USA	3520	138	1	*-3518*	*-138*	*-1*
Brazil	11283	5336	1	*-11278*	*-5336*	*-1*
Argentina	405	17758	1	*-405*	*-17757*	*-1*
Paraguay	524	29	0	*-524*	*-29*	*0*
Uruguay	150	0	0	*-150*	*0*	*0*
Rest of the world	555	220	60	9761	3726	32
Total	16436	23481	64 0	-6113	-19534	28

RED maize scenario

In the RED maize scenario an extreme supply disruption shock is modelled in which in addition to the Americas also the imports of the EU from the Western Balkans (and other countries) are no longer possible (see Table 6.9). This amounts to an import reduction of about 1.6 million tons of maize. Although this presents an extreme shock, it should be recognized that Table 6.9 only refers to imports of maize into the EU-27 which come from outside the EU. However, in 2009 more than 80 per cent of the total maize imports by EU Member States came from other EU Member States (intra EU trade dominates the market). Some Member States are significant importers and have been recently (2009) reliant for more than 20 per cent of their imports on the world market, namely Italy, Spain, Portugal and UK.

Table 6.9: Maize trade changes in EU maize imports in RED maize scenario compared to the 2020 baseline

	Baseline (2020)	Scenario RED (2020)
	Maize [1000 t]	Maize *[D to REF]*
Main exporters		
USA	0.45	*-0.45*
Brazil	1.55	*-1.55*
Argentina	2.13	*-2.13*
Rest of the countries		
Western Balkans	1600.04	*-1600.04*
All other countries	1.64	-1.64
Total	*1605.81*	*-1605.81*

---

[44] See for details about the specific countries which could act as alternative suppliers in the trade impact analysis of the ORANGE soya scenario as this is presented in Chapter 5.

6.3.2 Balancing of effects: substitution and displacement

The livestock impact assessment tool used is a *comparative-static partial-equilibrium model,* which helps to preserve the consistency of the analysis. One implication of this is that agricultural markets are analysed in a specific point in time and in equilibrium. This in turn implies that the 'market clearing' condition will be satisfied in each market. Therefore supply equals demand in each and every market, including feed ingredient markets other than soy. In the analysis a large host of interaction effects is taken into account, as also other sectors respond to the shocks at the soy and maize markets. Another property of the tool is that it ensures that feed mix used (in the EU) has the nutritional properties that satisfy the needs coming from the livestock sector, which sustain their equilibrium level of production.

The shocks to the EU soy and maize markets coming from the simulated supply disruptions generate a complex pattern of responses and interaction effects, which are difficult to disentangle in detail. The main mechanism, however, is that deficit in protein (soy) or energy (maize) that arises due to a supply disruption will be "solved" for in different ways, such as by:

a) additional imports from non-disrupted markets of soy or maize and/or feed ingredients that operate as substitutes;
b) lower exports from the EU of substitutes (and/or of soy)[45],
c) lower use of soy and maize products in feed rations (i.e. less soy and maize use in compound feed and/or on-farm direct feeding of soybeans or maize);
d) increases in domestic production in the EU of soybeans, maize and/or feed substitutes and also of roughage.

Finally, as feed ingredient prices will rise, this might induce an overall decline in demand for feed due to the declining profitability of the livestock sector and declining demand from consumers, which might in turn lead to a decline in livestock production. Therefore, there are different levels of analysis to take into account, processing of oilseeds playing an important role. In this section the focus will be on providing more insight into points (a) to (c). Note that point (a) has already been addressed in the previous section, which reported the supply disruptions (in terms of volumes of bilateral trade flows to EU that were interrupted and increased imports coming from alternative suppliers). Since relatively small impacts were found for the RED maize scenario, the main emphasis will be on the two long term soy scenarios.

Figure 6.3 presents the main trade substitution effects from the perspective of the EU-27. As Figure 6.3 shows as a response to the supply reduction at the soy market, a rapid increase in net imports of non-soy oilseeds, such as rapeseed and sunflower products (seeds and cakes), and pulses is observed. Also net imports of maize and wheat increase considerably[46]. Partly this will be due to the increased demand for these products within the EU. Another factor could be a change in land use in the EU. As Figure 6.3 further shows, domestic production is also boosted especially in the case of pulses, rapeseed and sunflower cakes. These products

---

[45] Here substitutes can play an important role, being 'wheat export displacement' a typical case, as we will see later on.

[46] An increase in net imports does not necessarily mean that actual imports increase. When a country is a net exporter of a product (such as is the EU for cereals) a reported increase in net imports means that such a country reduces the amount it exports to third countries, using the crop to provision increased domestic demand.

add up to a total of 1 mln t of additional production plus imports in the BLUE soy scenario, and 8.5 mln t in the RED soy scenario.

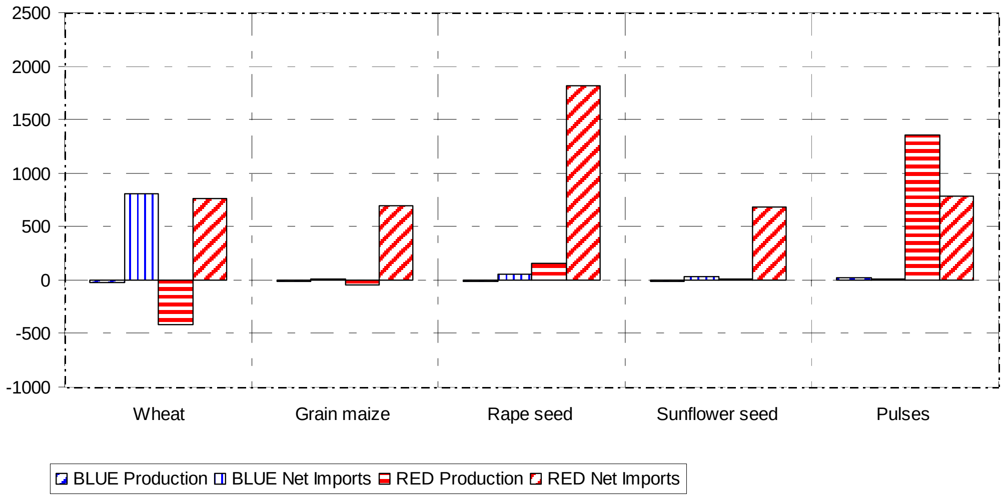

Figure 6.3: EU-27 production and balance of trade effects for non-soy products (in ‘000 t absolute changes vs. the 2020 baseline) for BLUE soy and RED soy scenarios

Figure 6.4 presents the induced adjustments in EU maize production as a result of the RED maize scenario. As can be derived from the figure the total change in production compensates about two thirds of the import deficit generated due to the simulated maize market supply disruption. The remainder of the gap is filled by a decline in the EU net exports and some substitution between feed ingredients.

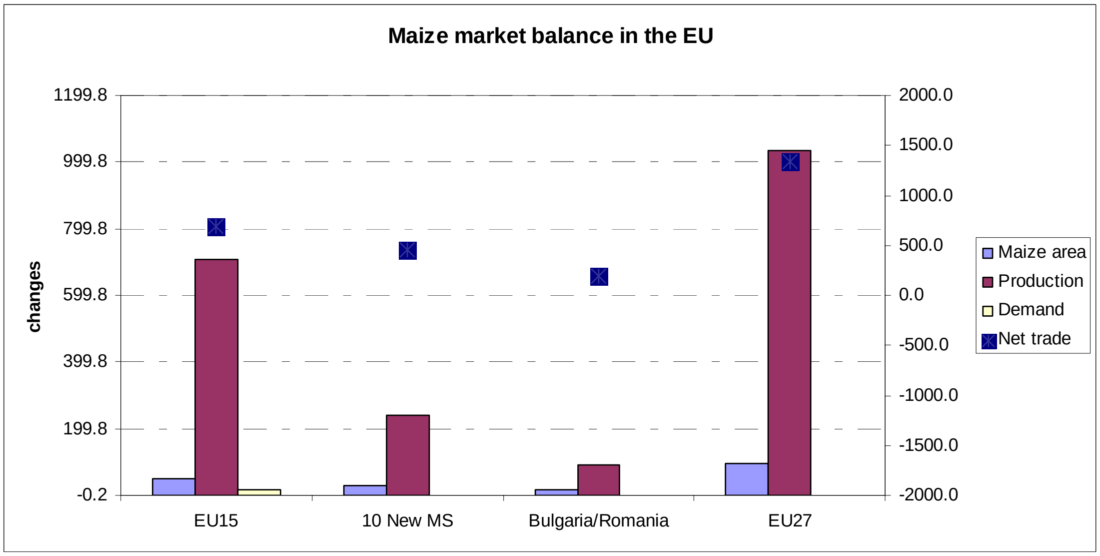

Figure 6.4: EU-27 maize production effects (in ‘000 t absolute changes vs. the 2020 baseline) for RED maize scenario

6.3.3 EU crop production and land use effects

It has already been touched upon that as a response to a feedstuff supply disruption the EU crop production will undergo adjustment. The first interesting thing to be observed is that in response to a soybean price increase, soybean production increases considerably in the EU, mostly in the RED scenario. Since the livestock impact assessment tool (CAPRI) does not have explicit capacity or feasibility production constraints (i.e. land suitability), the results obtained have been thoroughly discussed with experts. The conclusion is that results seem to be plausible and in line with the expectations, and supports the finding that high soy price increases would motivate increases in soybean production within the EU in the medium to long run.

As is shown in Table 6.10, in the BLUE scenario soybean production increases by 8% (0.14 mln t). Some production expansion is observed in Romania, Italy and France, with marginal increases in a few other Member States such as Spain[47], the UK, Hungary and Bulgaria.

---

[47] Baseline and scenario results for cultivation of soybeans have been confirmed by experts. Currently the main reason for an ‘almost zero’ cultivation of soybeans and partly rapeseed in Spain is due to low prices and not to agronomic conditions (non-cited source from Spain)

Table 6.10: Changes in EU market balances for soybeans in BLUE scenario compared to the 2020 baseline

	Reference year (2020)				Scenario **BLUE** (2020)			
	Soy area [1000 ha]	Production [1000 t]	Demand [1000 t]	Net trade [1000 t]	Soy area *[Δ to REF]*	Production *[Δ to REF]*	Demand *[Δ to REF]*	Net trade *[Δ to REF]*
Austria	40.5	115.6	40.8	74.8	3.2	10.0	1.5	8.5
Belgium-Lux.			1363.5	-1363.5			30.2	-30.2
Denmark			118.0	-118.0			2.6	-2.6
Finland			118.0	-118.0			2.4	-2.4
France	210.1	539.7	960.9	-421.3	7.0	21.3	20.3	0.9
Germany			4305.7	-4305.7			89.4	-89.4
Greece			336.7	-336.7			9.0	-9.0
Ireland			42.8	-42.8			1.8	-1.8
Italy	143.9	564.8	1299.2	-734.5	7.8	34.2	31.8	2.4
Netherlands			4133.1	-4133.1			112.4	-112.4
Portugal			1172.5	-1172.5			28.6	-28.6
Spain	26.3	77.4	2753.1	-2675.7	1.2	4.3	95.4	-91.1
Sweden			3.8	-3.8			0.1	-0.1
United Kingdom	9.5	41.8	746.6	-704.9	0.3	1.5	18.7	-17.2
EU15	430.2	1339.2	17394.7	-16055.5	19.5	71.2	444.1	-372.9
Cyprus			1.6	-1.6			0.0	0.0
Czech Republic	7.6	12.5	28.1	-15.6	0.0	0.1	0.1	0.0
Estonia			0.3	-0.3				
Hungary	20.5	51.1	82.4	-31.3	0.2	0.6	-0.5	1.1
Latvia	0.7	1.9		1.9	0.0	0.0		0.0
Lithuania			10.3	-10.3			0.0	0.0
Malta			1.1	-1.1				
Poland	0.0	0.1	6.3	-6.3			0.0	0.0
Slovac Republic	7.2	11.5	28.5	-17.0	0.0	0.1	0.1	0.0
Slovenia	0.1	0.3	2.6	-2.2			0.0	0.0
10 New MS	35.7	77.4	161.1	-83.7	0.3	0.8	-0.4	1.2
Bulgaria	0.2	0.6	5.4	-4.9	0.0	0.2	0.2	0.0
Romania	79.7	240.4	291.0	-50.7	22.3	64.7	7.4	57.2
Bulgaria/Romania	79.9	240.9	296.5	-55.6	22.3	64.8	7.6	57.2
EU27	545.8	1657.6	17852.3	-16194.8	42.2	136.8	451.3	-314.5

As can be further inferred from Table 6.10, in the BLUE scenario about 50% of the expansion in land use for cultivation of soybeans is accounted for in the EU-15 (France and Italy), the other 50% occurring in the EU-10, Bulgaria and Romania.

Table 6.11 shows soybean processing and soymeal balances at Member State level for the BLUE soy scenario. There are clearly large differences between production and demand, which is balanced by net imports. As Table 6.11 shows all Member States are net importers of soymeal, but whereas countries like Poland, the Czech Republic and Hungary mainly rely on imports of soymeal to feed their livestock, Romania processes large parts of their demand and is less dependent of soy imports. Germany and Netherlands show more developed processing capacity, since they mostly import soybeans and not cakes for their feeding industry.

.

Table 6.11: Changes in EU market balances for soymeal in BLUE scenario compared to the 2020 baseline

	Reference year (2020)				Scenario **BLUE** (2020)			
	Soybeans processed [1000 ha]	Production [1000 t]	Demand [1000 t]	Net trade [1000 t]	Soybeans processed *[Δ to REF]*	Production *[Δ to REF]*	Demand *[Δ to REF]*	Net trade *[Δ to REF]*
Austria	15.4	11.7	406.1	-394.5	0.4	0.3	16.1	-15.8
Belgium-Lux.	1353.9	1137.2	1952.2	-815.0	29.8	25.0	81.8	-56.8
Denmark	61.1	51.3	1497.8	-1446.5	1.3	1.1	66.0	-64.8
Finland	116.4	88.4	134.3	-45.9	2.3	1.8	5.2	-3.5
France	809.9	615.5	5495.6	-4880.2	16.1	12.2	233.6	-221.4
Germany	4294.4	3607.3	5178.4	-1571.1	89.1	74.8	221.7	-146.9
Greece	336.7	282.8	485.4	-202.5	8.9	7.5	21.4	-13.9
Ireland	29.3	24.6	430.9	-406.3	0.8	0.7	17.2	-16.5
Italy	1205.5	1012.6	4249.8	-3237.2	27.4	23.0	183.6	-160.5
Netherlands	3953.7	3321.1	3602.2	-281.1	107.2	90.1	158.2	-68.1
Portugal	1142.2	959.4	996.9	-37.5	27.4	23.0	45.2	-22.2
Spain	2540.4	2133.9	6107.4	-3973.5	90.1	75.6	270.0	-194.4
Sweden	2.9	2.2	281.6	-279.4	0.1	0.0	10.3	-10.3
United Kingdom	648.6	544.8	1969.3	-1424.4	14.9	12.5	64.7	-52.1
EU15	16510.1	13792.9	32787.9	-18995.0	415.8	347.3	1394.9	-1047.6
Cyprus	1.1	0.8	136.9	-136.1			-1.7	1.7
Czech Republic	26.1	21.9	688.8	-666.9	0.1	0.1	-1.6	1.7
Estonia			36.2	-36.2			0.0	0.0
Hungary	2.4	2.0	464.4	-462.4	0.0	0.0	-2.7	2.7
Latvia			68.4	-68.4			-0.1	0.1
Lithuania	6.1	5.2	45.2	-40.1	0.0	0.0	-0.2	0.2
Malta	0.9		27.1	-27.1			0.0	0.0
Poland			2527.8	-2527.8			4.8	-4.8
Slovac Republic	13.2	11.1	166.5	-155.4	0.2	0.2	-0.3	0.5
Slovenia			92.2	-92.2			0.3	-0.3
10 New MS	49.7	41.0	4253.6	-4212.6	0.3	0.3	-5.2	5.5
Bulgaria	5.4	4.6	78.9	-74.3	0.1	0.1	1.3	-1.2
Romania	232.0	194.9	263.1	-68.2	6.5	5.5	3.5	2.0
Bulgaria/Romania	237.5	199.5	342.0	-142.5	6.7	5.6	4.8	0.8
EU27	16797.3	14033.4	37383.5	-23350.1	422.8	353.2	1607.1	-1253.9

Whereas in the BLUE soy scenario the structural adjustment in arable land use is limited, in the RED soy scenario strong land use changes are observed both with respect to soybeans as well as with respect to other feed crops, which can partly act as a substitute for soybeans. As Table 6.12 shows, overall in the EU-27 soybean production increases by about 155% or 2.5 mln t. The main part (about ¾) of this production expansion comes from increased planting areas (+126% or 0.7 mln ha), whereas the remainder comes from increases in yields per hectare.

As regards the impact on the demand for soybeans, it turns out that due to the shock and associated price increases for soybeans and its products the demand declines, in particular in Germany, The Netherlands and Spain, with lower reductions observed for Belgium, France and the UK (see Table 6.12). Demand and use of soybeans in the new Member States, which are anyway less reliant on soybeans, are only marginally affected. Note that for Member States which are not producers of soybeans, the change in demand mirrors the change in net trade (with a positive number usually indicating a reduction in imports). Interestingly, Italy becomes more or less self-sufficient under the RED soy scenario, with the expansion of its home production nearly fully covering its internal demand.

Table 6.12: Changes in EU market balances for soybeans in RED scenario compared to the 2020 baseline

	Reference year (2020)				Scenario **RED** (2020)			
	Soy area [1000 ha]	Production [1000 t]	Demand [1000 t]	Net trade [1000 t]	*Soy area [Δ to REF]*	*Production [Δ to REF]*	*Demand [Δ to REF]*	*Net trade [Δ to REF]*
Austria	40.5	115.6	40.8	74.8	*78.9*	*266.3*	*4.2*	*262.1*
Belgium-Lux.			1363.5	-1363.5			*-122.2*	*122.2*
Denmark			118.0	-118.0			*-21.0*	*21.0*
Finland			118.2	-118.2			*-24.2*	*24.2*
France	210.1	539.7	960.9	-421.3	*242.9*	*792.9*	*-144.5*	*937.4*
Germany			4305.7	-4305.7			*-453.8*	*453.8*
Greece			336.7	-336.7			*-8.4*	*8.4*
Ireland			43.1	-43.1			*2.1*	*-2.1*
Italy	143.9	564.8	1299.3	-734.5	*203.8*	*979.9*	*-32.6*	*1012.5*
Netherlands			4133.1	-4133.1			*-101.6*	*101.6*
Portugal			1172.5	-1172.5			*-60.3*	*60.3*
Spain	26.3	77.4	2753.1	-2675.8	*41.0*	*161.4*	*-252.5*	*413.9*
Sweden			5.7	-5.7			*-1.2*	*1.2*
United Kingdom	9.5	41.8	746.6	-704.9	*9.7*	*53.9*	*-52.7*	*106.6*
EU15	430.2	1339.2	17397.2	-16058.0	*576.3*	*2254.3*	*-1268.7*	*3522.9*
Cyprus			1.5	-1.5			*0.2*	*-0.2*
Czech Republic	7.6	12.5	28.1	-15.6	*4.8*	*9.7*	*3.0*	*6.7*
Estonia			0.3	-0.3			*0.0*	*0.0*
Hungary	20.5	51.1	77.9	-26.8	*21.2*	*60.7*	*-6.4*	*67.1*
Latvia	0.3	1.9		1.9	*0.1*	*1.1*		*1.1*
Lithuania			10.3	-10.3			*0.5*	*-0.5*
Malta			1.7	-1.7			*-0.1*	*0.1*
Poland	0.0	0.1	6.1	-6.0			*-0.4*	*0.4*
Slovac Republic	7.2	11.5	28.5	-16.9	*5.1*	*9.5*	*4.0*	*5.6*
Slovenia	0.1	0.3	2.6	-2.2	*0.0*	*0.2*	*-0.1*	*0.2*
10 New MS	35.7	77.4	156.9	-79.5	*31.2*	*81.2*	*0.7*	*80.5*
Bulgaria	0.2	0.6	5.4	-4.9	*0.2*	*0.6*	*-1.0*	*1.5*
Romania	79.7	240.4	294.6	-54.2	*78.8*	*238.8*	*-37.3*	*276.0*
Bulgaria/Romania	79.9	240.9	300.0	-59.1	*79.0*	*239.3*	*-38.2*	*277.6*
EU27	545.8	1657.6	17854.1	-16196.5	*686.5*	*2574.8*	*-1306.2*	*3881.0*

Table 6.13 provides the soybean processing and soymeal balances at Member State level for the RED soy scenario. There are clearly large differences between production and demand, which is balanced by net imports. As Table 6.13 shows, net trade (defined as exports minus imports) significantly increases, which is due to the strong decline in soymeal imports inherent in this scenario. Nevertheless, the EU remains a net importer. In particular Belgium, France, Germany, Italy, Netherlands, Spain and the United Kingdom are severely affected by the supply disruption.

Table 6.13: Changes in EU market balances for soymeal in RED soy scenario compared to the 2020 baseline

	Reference year (2020)				Scenario RED (2020)			
	Soybeans processed [1000 ha]	Production [1000 t]	Demand [1000 t]	Net trade [1000 t]	Soybeans processed *[D to REF]*	Production *[D to REF]*	Demand *[D to REF]*	Net trade *[D to REF]*
Austria	15.4	11.7	406.1	-394.5	*-3.4*	*-4.6*	*-266.3*	*261.7*
Belgium-Lux.	1353.9	1137.2	1952.2	-815.0	*-123.8*	*-335.6*	*-1418.4*	*1082.9*
Denmark	61.1	51.3	1497.8	-1446.5	*-6.1*	*-15.5*	*-797.6*	*782.2*
Finland	116.4	88.4	134.3	-45.9	*-24.6*	*-34.3*	*-95.3*	*61.0*
France	809.9	615.5	5495.6	-4880.2	*-159.7*	*-232.1*	*-3410.4*	*3178.3*
Germany	4294.4	3607.3	5178.4	-1571.1	*-452.0*	*-1103.0*	*-3325.2*	*2222.2*
Greece	336.7	282.8	485.4	-202.5	*-8.4*	*-68.9*	*-248.8*	*179.9*
Ireland	29.3	24.6	430.9	-406.3	*-0.5*	*-5.8*	*-270.9*	*265.1*
Italy	1205.5	1012.6	4249.8	-3237.2	*-83.4*	*-281.3*	*-2500.4*	*2219.1*
Netherlands	3953.7	3321.1	3602.2	-281.1	*-68.1*	*-788.6*	*-2625.9*	*1837.3*
Portugal	1142.2	959.4	996.9	-37.5	*-65.1*	*-257.4*	*-557.0*	*299.6*
Spain	2540.4	2133.9	6107.4	-3973.5	*-208.8*	*-614.3*	*-3184.5*	*2570.2*
Sweden	2.9	2.2	281.6	-279.4	*-0.6*	*-0.8*	*-210.6*	*209.8*
United Kingdom	648.6	544.8	1969.3	-1424.4	*-76.6*	*-172.0*	*-1528.2*	*1356.1*
EU15	16510.1	13792.9	32787.9	-18995.0	*-1281.0*	*-3914.2*	*-20439.4*	*16525.1*
Cyprus	1.1	0.8	136.9	-136.1	*0.1*	*0.1*	*-66.9*	*67.0*
Czech Republic	26.1	21.9	688.8	-666.9	*3.6*	*3.0*	*-357.1*	*360.1*
Estonia			36.2	-36.2			*-25.5*	*25.5*
Hungary	2.4	2.0	464.4	-462.4	*0.4*	*0.4*	*-280.5*	*280.9*
Latvia			68.4	-68.4			*-56.8*	*56.8*
Lithuania	6.1	5.2	45.2	-40.1	*0.8*	*0.6*	*-34.4*	*35.0*
Malta	0.9		27.1	-27.1	*0.0*		*-11.1*	*11.1*
Poland			2527.8	-2527.8			*-1608.2*	*1608.2*
Slovac Republic	13.2	11.1	166.5	-155.4	*7.2*	*6.0*	*-97.4*	*103.4*
Slovenia			92.2	-92.2			*-55.2*	*55.2*
10 New MS	49.7	41.0	4253.6	-4212.6	*12.1*	*10.1*	*-2593.1*	*2603.2*
Bulgaria	5.4	4.6	78.9	-74.3	*-1.0*	*-0.5*	*-32.1*	*31.6*
Romania	232.0	194.9	263.1	-68.2	*-33.0*	*-13.1*	*-112.8*	*99.7*
Bulgaria/Romania	237.5	199.5	342.0	-142.5	*-34.0*	*-13.6*	*-144.8*	*131.3*
EU27	16797.3	14033.4	37383.5	-23350.1	*-1302.9*	*-3917.7*	*-23177.3*	*19259.6*

The relatively large increase in soybean production found in the soy supply disruption scenarios is partly due to an increase in yields of 0.5% and 13% for the BLUE and RED scenarios, respectively, and partly to an expansion of the area of soy cultivated of 8% (42 thousand ha) and 126% (686 thousand ha). Figure 6.5 provides some further details about in which regions the expansion in soybean production is likely to take place. According to the estimations, the expansion of soybean production within the EU (in relative terms to existing production) will mainly take place in Romania, north of Italy (Lombardi, Emilia Romagna and Piemonte), south of France (Midi-Pyrenees, Aquitaine and Languedoc-Roussillon) and to a lesser extent in the south of Spain (Extremadura and Andalucía).

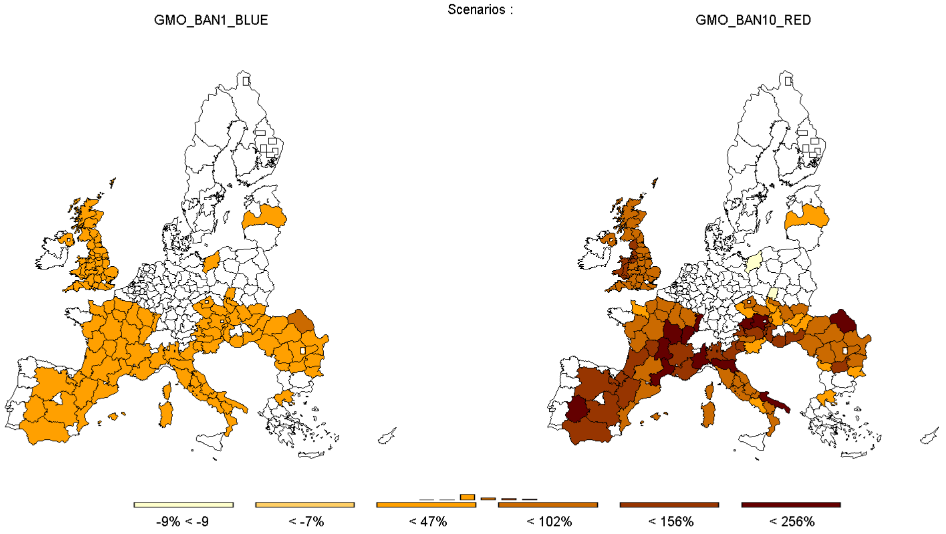

Figure 6.5: EU-27 soybean area across scenarios: BLUE and RED scenarios from the left to the right (in % differences vs. the 2020 baseline)

This area expansion has been cross-checked with experts for its feasibility. Already over the short run a rather large shift to soy production does not seem unfeasible from an agronomic point of view and in light of the relevant price increases.

As was denoted before, EU production of alternative substitute products for soy will also change. The three following figures provide some further insight into the land use changes found for rapeseed, pulses and fodder crops.

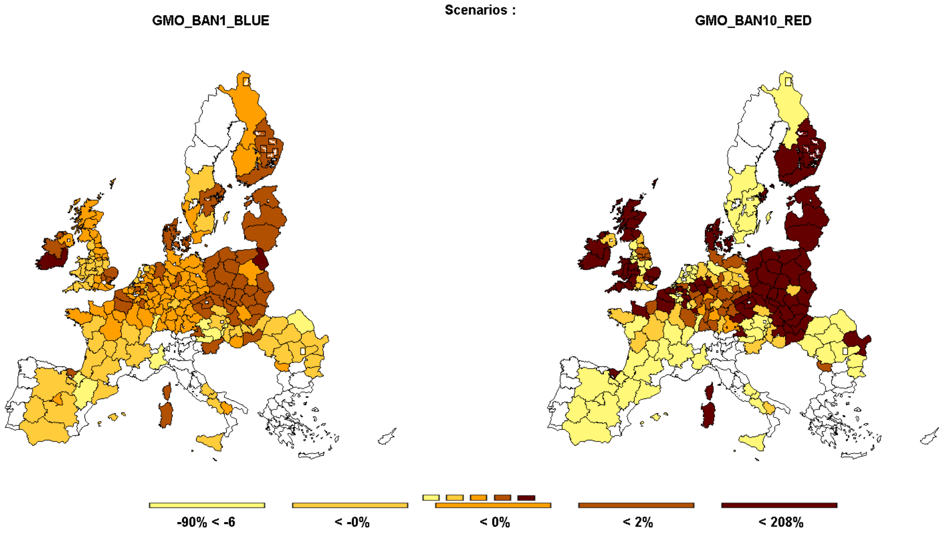

Figure 6.6: EU-27 rapeseed area across scenarios: BLUE and RED scenarios from the left to the right (in % differences vs. the baseline)

As Figure 6.6 shows with regard to rapeseed cultivation that very moderate effects are observed for the BLUE scenario. Basically they indicate a slight expansion of 0.19% in the EU-10 offset by a reduction of -0.16% in the EU-15 and -3% in Bulgaria and Romania. This is consistent with the pattern seen for soybeans in Figure 6.5.

For the RED scenario the picture does not change on average for the EU-27, but the distribution among Member States is different (see also Figure 6.5). Whereas the EU-10 experiences an increase in cultivation of around 10%, the EU-15 reduces the number of hectares by -3%. Bulgaria decreases the cultivation of rapeseed by -16% (with sunflowers and soft wheat as expanding activities) and Romania by -6% (with land going to soybean and fodder production).

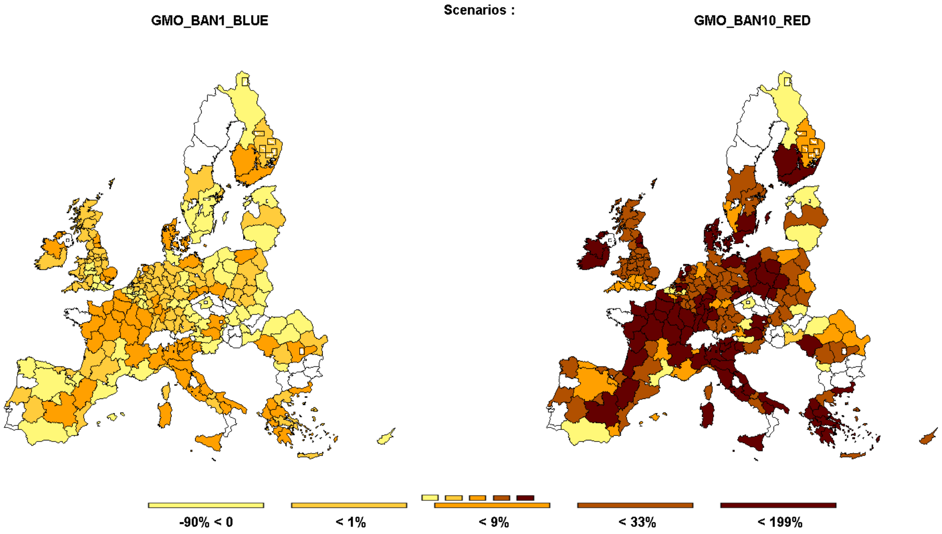

Figure 6.7: EU-27 pulses area across scenarios: BLUE and RED scenarios from the left to the right (in % differences vs. the baseline)

Figure 6.7 shows the land use impacts for pulses. With regard to pulses, land use does not change very much in the BLUE scenario, where most of the land substitution takes place within the oilseed aggregate (mostly soybeans and rapeseed, with the exception of sunflower in Bulgaria). In the RED scenario the situation changes radically, with very large increases in land use for pulses. On average, agricultural area for production of pulses increases by 28% (equivalent to 0.5 mln ha or 1.3 mln t, as presented in Figure 6.7). The expansion in pulses is slightly higher for the EU-15 (30%) than for the EU-10 (16%). In the case of Bulgaria production of pulses is expected to be reduced by -12% and in Romania to increase by 9%

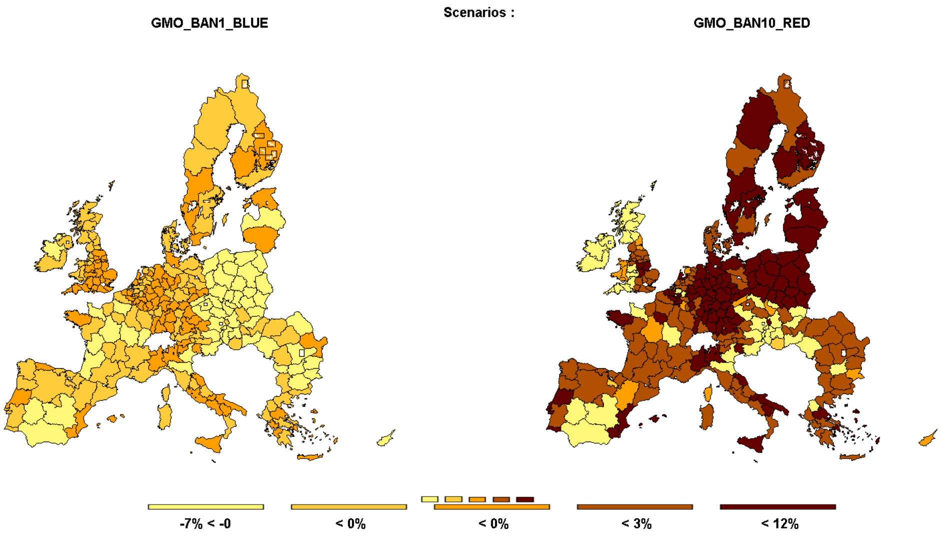

Figure 6.8: EU-27 fodder area across scenarios: BLUE and RED scenarios from the left to the right (in % differences vs. the 2020 baseline)

As Figure 6.8 shows, the production of fodder is positively affected in the RED soy scenario, especially in the northern European regions (around 6 to 7%). In the southern part of Spain, Ireland, Scotland, some northern Italian regions, Hungary and western part of Romania, fodder production is reduced. On average, the EU-27 cultivation of fodder increases by 0.4%.

Tables 6.14 and 6.15 summarize the EU-27 area changes for crop activity aggregates for both the BLUE soy and RED soy scenarios.

Table 6.14: EU-27 area changes for crop activity aggregates: BLUE scenario (in 1000 ha and % differences vs. the 2020 baseline)

	Reference year (2020)			Scenario **BLUE** (2020)		
	Area [1000 ha]	Yield [kg/ha or hd]	Supply [1000 t]	Area *[Δ to REF]*	Yield *[% to REF]*	Supply *[% to REF]*
Oilseeds	10126	2896	29320	*23.4*	*0.1%*	*0.4%*
Other arable crops	8224	19932	163918	*10.5*	*0.0%*	*0.1%*
Vegetables and Permanent crops	15091	11532	174026	*1.2*	*0.0%*	*0.0%*
Fodder activities	80522	23278	1874374	*5.8*	*0.1%*	*0.1%*
Set aside and fallow land	15188			*-10.3*		
Utilized agricultural area	187434			*0.0*		

In the BLUE scenario an increase of oilseed production (soybean and rapeseed), other arable crops (pulses) and fodder production is observed (see Table 6.14). Fallow land is slightly decreased.

Table 6.15: EU-27 area changes for crop activity aggregates: RED soy scenario (in 1000 ha and % differences vs. the 2020 baseline)

	Reference year (2020)			Scenario **RED** (2020)		
	Area [1000 ha]	Yield [kg/ha or hd]	Supply [1000 t]	Area [Δ to REF]	Yield *[% to REF]*	Supply *[% to REF]*
Cereals	56814	5754	326889	-487.4	0.7%	-0.2%
Oilseeds	10126	2896	29320	637.4	2.9%	9.3%
Other arable crops	8224	19932	163918	465.9	-5.8%	-0.4%
Vegetables and Permanent crops	15091	11532	174026	110.5	-0.5%	0.2%
Fodder activities	80522	23278	1874374	1443.6	2.7%	4.6%
Set aside and fallow land	15188			-769.6		
Utilized agricultural area	187434			1400.5		

Table 6.15 shows that in the RED soy scenario the domestic effects on land use are different. Note that an amount of about 0.8 million hectares of non-used agricultural land (fallow land) are put back into production, and that 1.4 million hectares are attracted from other sectors[48]. Apart of the already mentioned expansion of soy areas, in this scenario, the acreage expansion effects are on intensive grazing, rapeseed and pulses.

Table 6.16 provides the market balance and production impacts of the RED maize scenario, disaggregated at Member State level (measured as absolute deviations from the 2020 baseline). As Table 6.16 shows, under the RED maize scenario EU maize production increases about 1 million tons, which is mainly due to the area expansion. Due to the maize price increase there is a reduction in demand for maize, but in general this is limited.

---

[48] Here we observe the effect of the land supply function in CAPRI. This introduces a land supply elasticity differentiated per Member State and allows for some land expansion/contraction.

Table 6.16: Changes in EU market balances for maize in RED maize scenario compared to the 2020 baseline

	Reference year (2020)				Scenario RED maize			
	Maize area [1000 ha]	Production [1000 t]	Demand [1000 t]	Net trade [1000 t]	Maize area *[D to REF]*	Production *[D to REF]*	Demand *[D to REF]*	Net trade *[D to REF]*
Austria	165.3	2286.5	2656.4	-370.0	1.5	28.9	19.4	9.4
Belgium-Lux.	86.0	572.8	708.4	-135.6	0.7	6.7	-9.0	15.7
Denmark			134.1	-134.1			-2.9	2.9
Finland			194.0	-194.0			-0.8	0.8
France	1808.1	18301.4	6205.3	12096.1	16.6	223.5	-58.4	281.9
Germany	643.1	6212.9	7607.6	-1394.8	3.9	56.1	-13.8	69.9
Greece	236.3	2242.5	2550.7	-308.2	2.7	32.4	4.1	28.3
Ireland			535.5	-535.5			-4.6	4.6
Italy	1549.3	14749.4	13079.2	1670.2	10.9	151.8	108.7	43.1
Netherlands	44.9	551.9	2428.3	-1876.4	0.5	7.4	-10.7	18.1
Portugal	65.9	505.9	1829.7	-1323.8	1.5	15.7	9.0	6.6
Spain	447.3	6033.9	10104.0	-4070.2	11.7	183.0	-38.5	221.5
Sweden			94.1	-94.1			1.7	-1.7
United Kingdom			1790.2	-1790.2			12.1	-12.1
EU15	5046.1	51457.0	49917.6	1539.5	50.0	705.4	16.2	689.1
Cyprus			278.1	-278.1			-7.6	7.6
Czech Republic	118.8	868.0	903.9	-35.9	2.6	21.4	-30.2	51.6
Estonia			131.6	-131.6			-1.8	1.8
Hungary	1141.2	8031.0	3929.7	4101.3	14.2	126.2	-43.7	169.9
Latvia			22.6	-22.6			-0.7	0.7
Lithuania	2.7	9.7	89.1	-79.4	0.0	0.1	-3.6	3.6
Malta			71.1	-71.1			-1.3	1.3
Poland	662.0	4138.4	3942.6	195.8	11.3	81.9	-106.9	188.8
Slovac Republic	155.1	948.2	593.5	354.6	1.0	8.8	-11.7	20.4
Slovenia	37.0	294.6	354.4	-59.8	0.3	3.6	-5.9	9.4
10 New MS	2116.7	14289.9	10316.5	3973.4	29.5	241.8	-213.2	455.1
Bulgaria	202.6	1181.0	979.1	201.9	1.1	8.6	-12.7	21.3
Romania	2084.2	8764.6	7469.2	1295.3	15.0	80.4	-89.1	169.5
Bulgaria/Romania	2286.8	9945.6	8448.4	1497.2	16.1	89.0	-101.8	190.8
EU27	9449.7	75692.4	68682.4	7010.0	95.7	1036.2	-298.8	1335.0

Table 6.17 shows the domestic effects on land use for the RED maize scenario, with an expansion of the cereals area in this case, mainly caused by the expansion of the EU's domestic maize production. Also the area devoted to oilseeds slightly increases. All in all, changes in area allocation are minor. Also yield effects are marginal.

Table 6.17: EU-27 area changes for crop activity aggregates: RED maize scenario (in 1000 ha and % differences vs. the 2020 baseline)

	Reference year (2020)				Scenario **RED_MAIZE** (2020)		
	Area	Yield	Supply		Area	Yield	Supply
	[1000 ha]	[kg/ha or hd]	[1000 t]		*[D to REF]*	*[% to REF]*	*[% to REF]*
Cereals	56814	5754	326889		452.40	0.99%	1.8%
Oilseeds	10126	2896	29320		61.52	-0.33%	0.3%
Other arable crops	8224	19932	163918		89.66	-1.61%	-0.5%
Vegetables and Permanent crops	15091	11532	174026		-5.43	0.03%	0.0%
Fodder activities	80522	23278	1874374		-258.55	0.12%	-0.2%
Set aside and fallow land	15188				-195.07		
Utilized agricultural area	187433.98	13705.59	2568893.75		144.53		

The regional changes in maize supply (evaluated as percentage changes as compared to the 2012 baseline) are provided in Figure 6.9, which provides some further detail to the quantity changes that were already reported in Table 6.16.

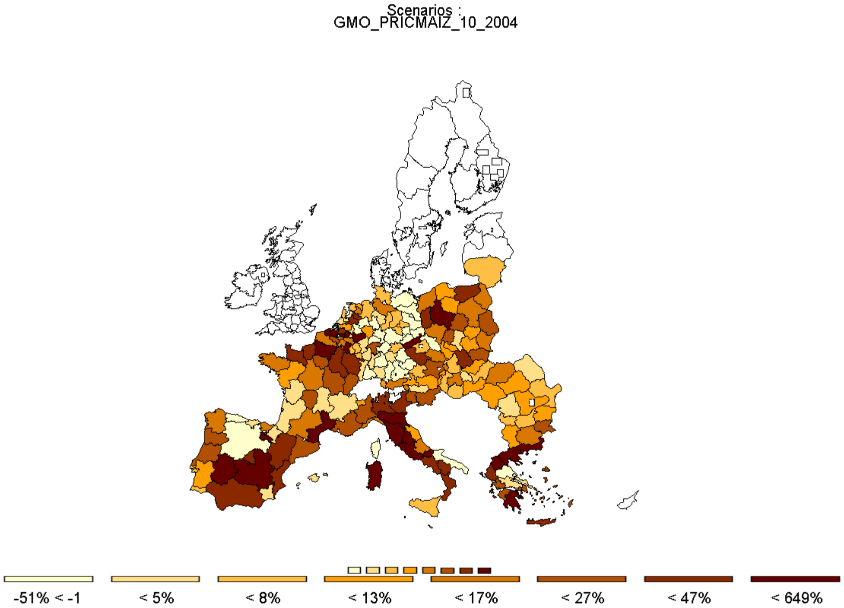

Figure 6.9: Maize production in EU-27: % differences in maize supply as compared to the 2012 baseline

6.3.4 Impacts on the EU livestock industry

In the previous sections, the effects of a supply disruption have been traced all through the system: from the changes in the EU trade balance for soy products, through price effects and, finally, the supply and land use changes for feed commodities. In this section the focus is on the economic effects on different livestock categories. Because the main impacts were found for the RED soy scenario, the impacts of this scenario will be given particular attention in the following discussion.

RED soy scenario

In assessing the impact on the livestock sector of the market disruption associated with the RED scenario, the impact on the costs of feed evaluated at the level of specific livestock activities should be noted first (see Table 6.18). As Table 6.18 shows, this impact varies from a 3% cost increase for feed used by the laying hens sector to a 26% increase of the feed costs for the sheep and goat fattening sector. The heterogeneity in feed cost increases over different livestock sectors reflects both the differences in feed composition as well as the net result of the substitution of feed ingredients in such a way as to minimize the feed cost increase, while still ensuring that the nutritional constraints and requirements are satisfied. As can be further deduced from Table 6.18 (for the base line) the share of feed costs in total costs of production varies from 35% (for sheep and goat fattening) to about 66% (for dairy cows, suckler cows and pig fattening), with laying hens and beef fattening having an intermediate position. Moreover, the share of total costs in total revenues or output value varies from 44% (for dairy cows) to about 95% (for suckler cows). As a result of the differences in the cost-revenue structure for the different livestock activities, the share of feed costs in the total final product value varies from less than 20% (for sheep and goat fattening) to about 60% (for suckler cows and laying hens). The difference between revenues and costs also shows significant variation over livestock activities (being relatively low for suckler cows and poultry fattening and high for dairy cows).

The percentage changes in costs and revenues reported in Table 6.18 reflect the differences in cost-revenue structure of livestock activities as discussed above and the market responses as included in the final medium to long run equilibrium. As Table 6.18 shows, the percentage increase in revenues (on average 5.6%) is much less than the percentage increase in feed costs (on average more than 15%). Profitability as measured in terms of gross margin[49] declines (unweighted average -18%), with a significant variation over activities: for laying hens production the gross margin slightly increases, whereas for suckler cows it decreases by 75%, and for dairy cows is only marginally affected. Note that Table 6.18 shows per unit

---

[49] Note that gross margin equals revenues minus variable costs. From the gross margin still fixed costs associated with the primary production factors (labour, capital, land) has to be covered, with the remainder being pure profits. Whereas fixed factors may have a sunk character in the short run, in the longer run they need an adequate remuneration, and if not such farms may leave the sector (no successor). For this reason sometimes a distinction is made between the impact on competitiveness in the shorter run (where costs for fixed factors might have an imputed value character) and the longer run (where remuneration according to its real opportunity costs is necessary to ensure economic viability of the production activity). Note that the intensive livestock sector is known to often be a capital intensive production activity (i.e. having a large share of fixed costs and have relatively small profit margins).

values. Changes in gross margin will affect the economic viability of livestock production activities (competitiveness) and induce adjustments in scale (with suckler cow production likely to be shrinking most). It is the interactions of demand and supply for livestock products (and consumers adjusting their consumption level as well as consumption mix of different meats) which explain the final equilibrium achieved in the livestock product markets. As a result of this, one sector might increase its profitability, whereas all livestock sectors together lose profits as a result of the input cost increases.

Table 6.18: Impact of the feed cost increase on the livestock sector for the RED soy scenario

	Reference year (2020)					Scenario RED (2020)				
	Revenues [€/hd]	Feed costs [€/hd]	Remonte [€/hd]	Other costs [€/hd]	Gross margin [€/hd]	Revenues [€/hd]	Feed costs [€/hd]	Remonte [€/hd]	Other costs [€/hd]	Gross margin [€/hd]
Dairy cows production activityhigh yield	2986	861	202	235	1687	*4%*	*19%*	*2%*	*0%*	*-3%*
Beef meat production	863	322	365	50	126	*6%*	*13%*	*8%*	*2%*	*-16%*
Suckler cows production activity	659	410	184	30	36	*5%*	*15%*	*0%*	*0%*	*-75%*
Pig fattening activity	127	66	21	13	27	*8%*	*18%*	*12%*	*-2%*	*-14%*
Sheep and goats activity for fattening	74	13	14	10	37	*7%*	*26%*	*50%*	*-2%*	*-14%*
Poultry fattening activity	2.4	1.4	0.1	0.7	0.3	*6%*	*13%*	*4%*	*-1%*	*-7%*
Laying hens production activity	14.9	8.6	0.1	2.5	3.7	*3%*	*3%*	*4%*	*0%*	*3%*

Source: own calculations based on CAPRI model database

Table 6.19 presents the production effects for livestock products at a Member State level. They can be interpreted as providing information on the competitiveness of livestock production in different Member States (with competitive regions being able to maintain or improve their relative position). The results should be carefully interpreted. In 32 out of 135 cases (27 Member States times 5 products) the percentage change as compared to the baseline is greater than 5 per cent, whereas in the rest (about 75%) it is smaller. Note that in many cases where the percentage change is greater than 5 per cent, the Member State's share in the EU production is very low. This implies that the impact of such a percentage change, although of considerable magnitude, has only a limited impact in absolute terms (that is, in terms of change in quantity of production). On the contrary, small percentage changes in Member States with a significant share in EU-27 production are likely to have a more important impact on the EU's total adjustment in the volume of livestock production. As the Table 6.19 shows, Member States being important producers that are relatively heavily affected are Belgium and the UK. They are followed by Italy, which is a large beef and pork producer, and a 5% decline, for example, implies a significant absolute amount. When looking to factors explaining this impact, it turns out that already initially the livestock activities in these Member States are relatively reliant on soymeal protein. At the same time a significant increase in land scarcity was observed. For example, the land rent in Belgium was twice as large as that what was observed for the EU-27's average increase (due to increased scarcity of land, which is needed for feed and roughage production). Note also that when Member States are not large producers from an EU perspective, nevertheless from a national perspective their livestock sectors can still be heavily affected. Notable examples are Portugal, the Czech Republic, Estonia and Latvia.

Table 6.19: Impact on meat production at MS level for the RED soy scenario

	Baseline (2020)					Scenario **RED** (2020)				
	Beef	Pork	Sheep & Goat Meat	Poultry	Eggs	Beef	Pork	Sheep & Goat Meat	Poultry	Eggs
	[1000 t]	[1000 t]	[1000 t]	[1000 t]	[MM t]	*[% diff.]*	*[% diff.]*	*[% diff.]*	*[% diff.]*	*[% diff.]*
Austria	180	497	7	140	86	0.4%	5.3%	1.6%	3.0%	1.3%
Belgium-Lux.	280	1178	2	258	242	-11.6%	-26.1%	-11.1%	-0.5%	1.6%
Denmark	112	1903	2	273	94	-4.7%	1.4%	-4.1%	-3.9%	-1.7%
Finland	77	183	1	106	56	-2.4%	-0.4%	-7.1%	-2.9%	0.4%
France	1706	2615	106	2335	1073	-3.2%	-0.8%	-1.1%	0.4%	0.2%
Germany	966	4792	50	1380	773	-4.1%	-2.7%	-0.8%	-4.0%	0.9%
Greece	46	103	101	191	125	-1.1%	2.8%	-1.9%	-1.1%	0.5%
Ireland	643	201	48	114	40	-0.4%	1.3%	-2.8%	-1.6%	-0.4%
Italy	949	1615	25	1087	996	-3.5%	-5.2%	-5.4%	1.1%	1.0%
Netherlands	338	1513	24	547	511	-2.8%	-1.9%	1.2%	-5.2%	-3.3%
Portugal	127	299	18	294	139	-6.7%	-4.7%	-5.3%	-12.1%	-2.6%
Spain	721	3838	204	1691	1112	-1.6%	3.5%	-1.5%	0.6%	-0.6%
Sweden	128	265	4	120	105	-3.8%	-6.2%	-7.8%	-7.2%	1.1%
United Kingdom	818	659	297	1989	792	-4.1%	-16.0%	-11.6%	-13.2%	-1.0%
EU15	7091	19662	888	10524	6144	-3.3%	-2.6%	-5.1%	-3.6%	-0.2%
Cyprus	5	64	7	42	10	-1.0%	-9.7%	-4.6%	1.0%	0.0%
Czech Republic	59	418	3	321	148	-5.3%	-7.3%	-12.6%	-10.5%	-1.3%
Estonia	12	35	0	13	7	-7.0%	-11.1%	-10.5%	-13.6%	-12.2%
Hungary	33	466	8	400	121	0.5%	-0.4%	-2.8%	3.7%	0.4%
Latvia	19	25	1	1	20	-14.4%	-12.9%	-19.6%	1.1%	0.5%
Lithuania	33	109	1	42	42	-1.7%	0.5%	-1.7%	0.2%	0.0%
Malta	2	8	0	7	5	-1.3%	-8.0%	0.0%	-1.8%	0.7%
Poland	371	2490	4	1192	512	-5.9%	-4.0%	-6.9%	-4.2%	-0.1%
Slovac Republic	32	77	3	112	71	0.0%	-0.3%	-4.8%	-2.6%	-0.1%
Slovenia	53	28	0	72	26	-2.0%	1.8%	-18.8%	-1.0%	0.3%
10 New MS	618	3719	28	2202	963	-4.9%	-3.9%	-5.9%	-3.4%	-0.3%
Bulgaria	58	30	53	55	58	-1.5%	1.2%	-1.3%	-0.2%	-0.1%
Romania	216	362	85	338	308	-0.7%	0.1%	-2.6%	-1.9%	0.1%
Bulgaria/Romania	274	392	138	393	366	-0.8%	0.2%	-2.1%	-1.7%	0.1%
EU27	7984	23774	1054	13119	7472	-3.4%	-2.8%	-4.7%	-3.5%	-0.2%

BLUE soy scenario

Table 6.20 presents the corresponding results for the BLUE soy scenario, which not surprisingly shows much smaller deviation from the baseline. The percentage changes in costs and revenues reported in Table 6.20 reflect the differences in cost-revenue structure of livestock activities as discussed above and the market responses as included in the final medium to long run equilibrium. In comparison to the results found for the RED soy scenario, the percentage increase in revenues (on average less than 0.1%), in feed costs (on average less than 0.1%) and in gross margin are of a negligible order (and within the usual error margin implied in the impact assessment modelling tool used). As Table 6.20 shows, the effects might be even slightly positive for farmers (see reported marginal positive changes in gross margin).

Table 6.20: Impact of the feed cost increase on the livestock sector for the BLUE soy scenario

	Reference year (2020)					Scenario BLUE (2020)				
	Revenues [€/hd]	Feed costs [€/hd]	Remonte [€/hd]	Other costs [€/hd]	Gross margin [€/hd]	Revenues [€/hd]	Feed costs [€/hd]	Remonte [€/hd]	Other costs [€/hd]	Gross margin [€/hd]
Dairy cows production activityhigh yield	2986	861	202	235	1687	*0.1%*	*-0.1%*	*0.1%*	*0.0%*	*0.2%*
Beef meat production	863	322	365	50	126	*0.1%*	*-0.1%*	*0.2%*	*0.0%*	*0.8%*
Suckler cows production activity	659	410	184	30	36	*0.1%*	*-0.1%*	*0.0%*	*0.0%*	*3.1%*
Pig fattening activity	127	66	21	13	27	*0.0%*	*-0.1%*	*0.1%*	*-0.1%*	*0.4%*
Sheep and goats activity for fattening	74	13	14	10	37	*0.0%*	*-0.3%*	*0.5%*	*0.1%*	*-0.1%*
Poultry fattening activity	2.4	1.4	0.1	0.7	0.3	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.6%*
Laying hens production activity	14.9	8.6	0.1	2.5	3.7	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.1%*

Source: own calculations based on CAPRI model database

Further impacts for the BLUE soy scenario on meat production are not reported in a separate table, since production effects turned out to be negligible for all livestock categories. This is not surprising, since we already observed that the changes in the feed market would be marginal, and as a result one would also not expect any major effects to downstream sectors. Since a reduction in the imports of soybeans because of asynchronous approval with regard to one supplier is mostly replaced by other exporters, in the BLUE soy scenario the volume of soybeans used for feed only slightly decreases due to the price increases. Moreover, the soymeal market is not affected: most imports of meals from South America continue flowing into the EU, and the EU crushing industry expands capacity due to attractive margins and availability of soy. In general, a slight replacement of feeding bulks rich in proteins through cereal-based compounds is observed.

RED Maize scenario

The impacts on feed costs, revenues, and gross margin for different livestock activities are presented in Table 6.21. As Table 6.21 shows, just like in the BLUE soy scenario, the final impacts turn out to be very limited, with hardly any change exceeding more than 0.5 per cent, and most observed percentage changes even being smaller.

Table 6.21: Impact of the feed cost increase on the livestock sector for the RED maize scenario

	Reference year (2020)					Scenario RED Maize (2020)				
	Revenues [€/hd]	Feed costs [€/hd]	Remonte [€/hd]	Other costs [€/hd]	Gross margin [€/hd]	Revenues [€/hd]	Feed costs [€/hd]	Remonte [€/hd]	Other costs [€/hd]	Gross margin [€/hd]
Dairy cows production activityhigh yield	2986	861	202	235	1687	*0.0%*	*0.0%*	*0.1%*	*0.0%*	*0.0%*
Beef meat production	863	322	365	50	126	*0.1%*	*0.1%*	*0.1%*	*0.0%*	*0.0%*
Suckler cows production activity	659	410	184	30	36	*0.1%*	*0.2%*	*0.1%*	*0.0%*	*-0.9%*
Pig fattening activity	127	66	21	13	27	*0.1%*	*0.3%*	*0.1%*	*0.0%*	*-0.3%*
Sheep and goats activity for fattening	74	13	14	10	37	*0.0%*	*0.1%*	*0.1%*	*0.2%*	*-0.1%*
Poultry fattening activity	2.4	1.4	0.1	0.7	0.3	*0.1%*	*0.3%*	*0.1%*	*0.0%*	*-0.3%*
Laying hens production activity	14.9	8.6	0.1	2.5	3.7	*0.1%*	*0.3%*	*0.2%*	*0.0%*	*-0.1%*

Source: own calculations based on CAPRI model database

Just like for the BLUE soy scenario, further impacts for the RED maize scenario on meat production are not reported in a separate table, since production effects turned out to be negligible for all livestock categories. Given the marginal changes in the feed market already discussed, one would also not expect any major effects to downstream sectors.

6.4 Impacts on competitiveness and welfare

In this section the impacts on the livestock sector's competitiveness are further elaborated upon. The competitiveness issue has been already indirectly addressed in previous sections. For example, the impact of various supply disruptions on farm sales, costs of production and gross margins of the livestock sector have been discussed. These can all be argued to be indicators of competitiveness. Some further discussion of these results, nevertheless, will be provided here. Moreover, some information on the market-share indicator of competitiveness will be provided. The conditionality of the results obtained on the prevailing EU trade and agricultural policies will be also highlighted. In addition to the impact on the livestock sector, the impact on consumers will be further assessed. It was already noted previously that a significant part of the cost increases in feed and livestock production will be passed on to consumers. At the same time it was noted that the gross margins of livestock farms were negatively impacted. These impacts are analysed further below. Section 6.4.1 examines the relationship between gross margin and farm income. Section 6.4.2 discusses to what extent the impacts are conditional upon the EU import tariffs and import quotas that are considered to be in effect within the temporal framework of this study.

6.4.1 Competitiveness: a closer look at gross margin impacts

An important indicator of competitiveness is 'profitability', since an operation generating positive profits will be viable and able to preserve or even expand its position in the market. Gross margins can be interpreted as being an indirect indicator of profitability, but this needs further refinement. Gross margin is equal to revenues minus specific costs (feed, etc.) and other operating costs (upkeep of machinery, energy, contract work, taxes on land and buildings, etc.). The net margin results when subtracting depreciation from the gross margin. This net margin includes what is available for remunerating the primary factors of production (land, labour and capital), or the Farm Net Value Added. When subtracting from the Farm Net Value Added the amount of paid remuneration for land, capital and (non-family) labour, the result is farm income. If from this the cost imputed to unpaid family factors would be subtracted, the result would be the net economic margin (or profits). Although it is beyond the scope of this research to go in all details of farm accountancy, what the previous discussion shows is that the link between gross margin and profits, or gross margin and farm income, is indirect.

In order to interpret the impacts found on gross margin in a correct way, as a further step Tables 6.22 and 6.23 provide information about the Farm Net Value Added (expressed per 100€ of output) and Farm Income (also expressed in terms of 100€ of output)[50].

---

[50] The FADN (Farm Accountancy Data Network) database contains information on output and subsidies per enterprise; however, as regards costs, it only provides information referring to the farm as a whole. In this context, the contribution of each enterprise or activity to the farm income is not directly available. The EU FADN unit has constructed several models to estimate costs and margins, for a range of different products. However, here results are presented for the whole farms (as classified in certain farm types). There are some disparities in FADN recording among Member States, such as differences in farm size levels being part of the sampling, etc. which will be ignored here since our main aim is to illustrate some basics about livestock farm heterogeneity rather than providing a detailed comparative farm accountancy analysis.

Table 6.22: Farm net value added per 100€ of output in EU livestock sectors (at Member State level; averages for 2004-2007) *)

	Specialist milk	Specialist cattle	Mixed livestock	Specialist sheep and goats	Specialist granivores
Austria	85.2	61.3	41.1	*60.6*	33.6
Belgium - Lux.	77.7	44.1	32.9	0	11
Denmark	25.7		*27.8*		24.5
Finland	80.1	63.6			28.6
France	72.4	44.1	26.2	36.2	17.3
Germany	65.9	41.7	28.7	72.0	22.2
Greece		73.6	77.2	71.7	
Ireland	79.6	78.8		90.8	
Italy	88.9	45.7	49.6	62.8	44.8
Netherlands	58.1	41.2	20.9	23.1	14.4
Portugal	87.3	68.4	48.9	63.6	27.3
Spain	94.6	64.7	54.4	66.2	36.1
Sweden	46.3	31.5			18.7
United Kingdom	61.4	45.7	28.7	55.5	27.7
EU-15	71.0	54.2	39.7	54.8	25.5
Cyprus				35.2	
Czech Rep.	34.3	57.4	32.7		15.2
Estonia	52.1				
Hungary	43.7		27.9	37.0	19.3
Latvia	95.6		44.7		21.4
Lithuania	107.9		57.3		
Malta	*90.1*				*37.4*
Poland	91.1	47.9	35.1	53.8	24.7
Slovak Rep.	-81.3			24.1	
Slovenia	103.3	29.9	29.8	57.8	
10 new MS	59.6	45.0	37.9	41.6	23.6
Bulgaria					
Romania					
Bulgaria/Romania					
EU-15	71.0	54.2	39.7	54.8	25.5
EU-25	66.4	52.5	39.1	50.6	25.0
EU-27	66.4	52.5	39.1	50.6	25.0

**) Blank cells represent cases for which less than 3 observations were available. Italic numbers represent cases where 3 year observations were available. All other numbers represent 4-year averages. Note that averages for a group countries represent unweighted averages.*

Source: FADN data 2004-2007.

Table 6.23: Farm income per 100€ of farm output in EU livestock sectors (at Member State level; averages for 2004-2007) *)

	Specialist milk	Specialist cattle	Mixed livestock	Specialist sheep and goats	Specialist granivores
Austria	48.9	52.4	33.7	*49.3*	27.3
Belgium - Lux.	70.2	65.0	46.8		
Denmark	9.5		*2.1*		-0.7
Finland	38.0	44.8			20.4
France	25.5	30.8	17.5	25.1	9.8
Germany	28.3	23.6	14.8	40.6	10.9
Greece		66.4	73.1	66.6	
Ireland	41.0	64.5		77.3	
Italy	41.4	40.3	42.7	56.5	37.7
Netherlands	25.1	24.4	8.8	2.2	5.2
Portugal	32.0	57.8	43.1	56.5	23.9
Spain	49.8	58.1	50.0	59.2	31.4
Sweden	13.5	15.7			2.7
United Kingdom	22.6	28.2	12.1	33.2	13.4
EU-15	34.3	44.0	31.3	46.6	16.6
Cyprus				27.4	
Czech Rep.	13.8	27.5	7.2		0.5
Estonia	21.4				
Hungary	15.1		0.5	22.8	6.3
Latvia	43.3		39.9		7.8
Lithuania	62.1		56.2		
Malta	*26.4*				*31.5*
Poland	45.8	42.8	31.7	44.9	21.5
Slovak Rep.	-14.7			-10.5	
Slovenia	36.6	31.6	29.7	50.7	
10 new MS	27.8	33.9	27.5	27.0	13.5
Bulgaria					
Romania					
Bulgaria/Romania					
EU-15	34.3	44.0	31.3	46.6	16.6
EU-25	31.6	42.1	30.0	40.1	15.6
EU-27	31.6	42.1	30.0	40.1	15.6

**) Blank cells represent cases for which less than 3 observations were available. Italic numbers represent cases where 3 year observations were available. All other numbers represent 4-year averages. Note that averages for a group of countries represent unweighted averages.*

Source: FADN data 2004-2007.

What Tables 6.22 and 6.23 make clear is that the value added per 100€ of output differs over farm types. Although it should be recognized that there is no one-to-one relationship between farm types and livestock activities (as they were presented in previous sections), it is anyway clear from both tables that specialist granivore farms (or for that matter pigs and poultry farms) have relatively low net farm value added and farm income margins. Moreover, when looking to individual Member State data, there is a lot of variation, which suggests that in particular the intensive livestock industry is characterized by a certain degree of fragility. It should also be noted that the numbers presented at Member State level are averages, comprising an indicator which summarizes a whole distribution of individual farm outcomes. This implies that around the reported averages there are farms which perform better as well as worse. In the Member States with the most important pig and poultry sectors in the EU (Denmark, France, Germany, Italy, Netherlands, Spain, United Kingdom, and Poland), 5 out of 8 of them have a very low farm income per 100€ of output (varying between -€0.7 and €15 per 100€ of output). A reason for such low margins is not necessarily relative inefficiencies in production, but could also reflect a particular financial structure (e.g. farms financed with large amounts of debt or having low equity)[51]. When the full burden of even small losses in gross margin would fall on farm profits (as the final buffer), it can be seen that the impact on farm income could be substantial (e.g. a loss of €3 gross margin/€100 of output, as was for example found for pig production in the RED soy scenario; this would imply a 20% loss in farm income).

Summarizing, although in percentage terms the losses in gross margin (i.e. roughly varying between 0% and 15%) may suggest that the impacts are limited, the final impacts on farm income can be significantly higher. Most likely this will be the case for 5 out of 8 of the most important pork, egg and broiler producing Member States in the EU-27. Whereas the analysis provided above uses averages by Member State, a significant number of farms will perform below average, which means that an important fraction of the intensive livestock farms may potentially face larger income losses than those of the average farm.

6.4.2 Competitiveness: the role of policy and supply chain structure

As was explained when the CAPRI tool used for the EU livestock sector impact assessment was introduced (see Chapter 2), the results obtained with respect to the competitiveness of the EU livestock sector are conditional on the border protection and the extent to which this insulates the EU livestock sectors from external competitive pressure. Thus the fragility of (parts of) the EU livestock sector was already pointed to beforehand. Under the prevailing trade policy measures, the price structure for livestock products in the EU market is such that the protection of the border measures has remained an effective financial support. Should EU livestock product markets be further liberalized (see the Scenar 2020-II study, Nowicki et al., 2009), the current financial foundation of the livestock industry would no longer be guaranteed and the results contained in this study could drastically change[52].

---

[51] Farms with a low margin can still earn an adequate income if the farm scale is large. In general this is what is the case: farm scale in the pigs and poultry sector is relatively large for Member States with relatively low farm income margins.

[52] From a trade liberalization perspective (e.g. a new WTO agreement) it could be attractive to further liberalize livestock product markets (see planned quota abolition for dairy in 2015 as an example). However, within the context of this study it would be strange to ‘protect’ the EU (and its consumers) against EU unapproved GM soya and maize products, while at the same time one would allow free access to livestock products from the rest

With respect to competitiveness, in principle also the way the supply chain is structured could have its impact. In the current analysis, it is assumed that the actors in the supply chain are under a competitive regime of full competition. This implies that no account is made for market power. However, supply chains can include intricate dependencies and inside and outside sourcing possibilities. Asymmetries in market power relationships can imply that the burden of the impacts of feed cost increases will be carried by the weakest part of the chain. Moreover, market power relationships can preclude certain stages in the supply chain to pass on cost increases to the next stage. A detailed analysis of this is beyond the scope of this study.

6.4.3 Competitiveness: market share analysis

This section reports on the impacts that feedstuff supply disruption in the soy and maize market would have on the internal and external competitiveness of the EU. One indicator measuring competitive performance or changes in competitiveness is to measure how well a Member State succeeds in maintaining or improving its market share. This approach is followed in this section. Rather than supplying detailed tables, the main impacts will be summarized for three selected scenarios (BLUE, RED soy; RED maize) and for a range of livestock products (dairy, beef, sheep and goat, pork, poultry (broilers) and laying hens). Results are presented in terms of changes in a Member State's relative market share in production. For two reasons one should be careful in interpreting these competitiveness indicators. First, a country which increases its market share might still have to shrink production, because the decline in total production dominates the market share-increase-effect. Second, a country might show a large percentage change in its market share, but if it's initial market share is negligible, then the absolute impact in terms of change in the volume of production will also be negligible[53].

BLUE soy scenario (long term: 2020)

As was described before, in the BLUE scenario the soybeans coming from the USA are more or less completely replaced by soybeans and soymeal coming from other origins. Moreover, the reallocation of trade patterns turned out to have only very minor effects on prices. This implies that, as compared to the baseline, there are only minor changes in the feed ingredients supplied. This then also leaves the final impact on the livestock sector to be minor. This is also reflected in the market shares and competitive positions of Member States. For all products, except pork, changes in market shares are negligible. As regards the main pork producers, Spain is gaining market share (+6.34%) whereas Belgium and UK (which are less important producers) face a reduction of their market share by more than 10 per cent.

---

of the world, where these to a large extent will be produced using EU-unapproved events. Further liberalization of EU livestock markets could be attractive for consumers because they can than avoid to pay the price for having an environment with only non-GM and EU approved GM material. At the same time it would be detrimental for livestock farmers, since then they still will have to bear the burden of the feed cost increases of the EU policy (relative to the costs livestock producers elsewhere in the world face), without having longer the opportunity to pass on part a substantial part of these costs to their clients.

[53] See for changes in production for selected livestock products the maps provided in 6.3.2.5

RED soy scenario (long term: 2020)

The impact of the RED soy scenario is presented in Table 6.24, and shows the response in terms of market shares relative to the baseline; there is a diversity in the degree of this impact both between livestock activities within a country and between countries.

Table 6.24: Change in market share of animal activities within the EU-27 for the RED soy scenario (in %)

	% change in market share for RED scenario			
	beef	dairy	pigs	poultry
Austria	3.87	1.37	8.31	6.69
Belgium-Lux.	-8.54	-1.14	-24.04	3.10
Denmark	-1.36	0.51	4.27	-0.43
Finland	0.96	0.40	2.39	0.64
France	0.20	0.66	2.02	4.01
Germany	-0.75	0.14	0.07	-0.56
Greece	2.38	0.82	5.73	2.43
Ireland	3.08	1.19	4.23	1.91
Italy	-0.09	0.07	-2.51	4.70
Netherlands	0.56	0.49	0.90	-1.78
Portugal	-3.44	-1.03	-1.95	-8.94
Spain	1.83	1.14	6.46	4.20
Sweden	-0.41	-0.02	-3.51	-3.86
United Kingdom	-0.77	-2.12	-13.60	-10.08
EU15	0.04	0.11	0.16	-0.09
Cyprus	2.50	-0.34	-7.14	4.62
Czech Republic	-2.03	-0.58	-4.64	-7.24
Estonia	-3.77	-1.08	-8.59	-10.49
Hungary	3.96	0.41	2.40	7.39
Latvia	-11.44	-4.58	-10.47	4.78
Lithuania	1.70	-0.87	3.36	3.77
Malta	2.17	-1.21	-5.42	1.73
Poland	-2.61	-1.23	-1.22	-0.77
Slovak Republic	3.49	0.14	2.51	0.89
Slovenia	1.42	-0.54	4.69	2.56
10 New MS	-1.56	-0.98	-1.14	0.10
Bulgaria	1.92	0.04	4.10	3.35
Romania	2.79	0.43	2.90	1.58
Bulgaria/Romania	2.61	0.36	3.00	1.83

Source: own calculation based on CAPRI model output

RED maize scenario (long term: 2020)

Since the impacts of the RED maize scenario on the livestock sector were very minor, no separate discussion of market share changes in livestock production activities for Member States are reported.

6.4.4 Welfare analysis

Welfare analysis provides information about the impacts of the market disruptions on the economy or groups of actors in the economy. It can be interpreted as a kind of (static) cost-benefit analysis. As regards producers, they can be shown to measure the impact on (quasi-rents or) profits. Depending on the method of aggregation or disaggregation, welfare effects can be generated (or decomposed into effects) at different sector levels. On the consumer side (money metric) they provide a measure of the welfare loss experienced by consumer, because as a result of the feedstuff supply disruption they get relatively less product (than before the disruption) and have to pay more. Depending on the stage at which the money metric is measured, it can comprise not only pure consumer surplus, but also include certain retail and final processing stages (e.g. user surplus rather than consumer surplus). One thing that should be realized is that the CAPRI model provides so-called one-shot welfare impacts, which is due to its comparative static nature. As such these welfare impact measures are fine, but they do not take into account the length of the time period ('run') which occurs before the new equilibrium will exist. Given the dynamic nature of the economy and also the policies responding to this, it is not easy to determine this period in which a new equilibrium is attained. However, as is well-known from cost-benefit analysis (cf. principle of discounting) that this is important. For example, when assuming that this period would be 10 years (or 20 years) and the real interest or discount rate is equal to 4%, all welfare changes (as measured in absolute amounts of money) should be multiplied by a factor of 9.1 (or 14.6).

Table 6.25 provides an overview of the welfare impacts associated with six simulated feedstuff supply disruption scenarios. As regards the impact on agriculture (in terms of agricultural income), it should be noted that there are impacts of the supply disruptions on the livestock sector (which will in general be negative) and impacts on the arable sector (positive due to increasing soybean, other oilseed, and cereal prices, which result in increasing domestic production). Together these counteracting forces explain the limited impact found on total agricultural income, relative to the impact on consumers.

Table 6.25: Meat price changes in EU-27 for different supply disruption scenarios

	Beef [€/hd]	Pork [€/hd]	Sheep & Goat [€/hd]	Poultry [€/hd]
	% change to reference year			
ORANGE soya	0.6%	2.3%	1.3%	1.1%
BLUE soya	0.1%	0.1%	0.0%	0.0%
RED soya	5.1%	9.3%	7.0%	5.6%
RED maize	0.1%	0.1%	0.0%	0.1%

The impact on consumers (or consumer surplus), as measured by the money metric, turns out to show the most significant impacts (relative to taxpayers and agricultural producers). The impact on consumer welfare is mainly related to the price increases for meat products (see Table 6.24 for a brief overview). The loss in consumer welfare confirms the observation made earlier that farmers will be in the position to pass on a large part of the cost increases they are facing to consumers. As compared to the pre-shock situation, in the new equilibrium situation under the RED soy scenario consumers in EU-27 lose about 10.5 billion euro annually, which dominates all other effects. Moreover, when accounting for the long run nature of this equilibrium, an argument could be made that these welfare effects, as compared to the baseline, will be experienced for several years. For example (using assumptions discussed above), for a 10 (or 20) year period the discounted net present value of the loss to consumers would increase to a loss of 95.5 (or 153.3) billion euro.

Taxpayer costs hardly change, amongst others because the direct payments are kept fixed over scenarios (by definition).

Table 6.26: Welfare decomposition for selected soy and maize feedstuff supply disruption scenarios

	Tax payers cost (bln €)	Money metric (bln €)	Agricultural income (bln €)	Total (bln €)
GREEN soy *)	NA	NA	NA	NA
ORANGE soy	-0.08	-3.90	1.77	-1.72
ORANGE maize *)	NA	NA	NA	NA
BLUE soy	0.08	-0.18	0.24	0.74
RED soy	0.10	-10.50	0.50	-9.60
RED maize	0.10	-0.18	0.20	-0.05

Source: own calculations
**) No full welfare analysis calculation available*

The estimated welfare changes are in general relatively small for the BLUE soy and RED soy scenarios. For the EU-27 economy as a whole, there is even a slight gain of about 0.74 billion euro under the BLUE soy scenario and a small loss of 0.05 billion euro for the RED maize scenario.

No full welfare impact calculations are available for the GREEN soy and ORANGE maize scenarios. As regards the GREEN scenario, no modelling tool was applied and only the impacts at the level of the feed costs to livestock producers were estimated (but further impacts throughout the supply chain could not be determined). The feed costs calculated manually provide an estimate of the welfare impact on livestock farmers. In case of an incidental supply disruption, farmers will have limited possibilities to adjust in the short run (and will also most likely not be able to pass on part of the cost increase they are facing to consumers). In that case the impact on feed costs will in the short run also be the main negative welfare impact of the GREEN soy scenario. In the long run the economy will return to its initial equilibrium and therefore all welfare effects will be zero. With respect to the ORANGE maize scenario no full welfare impact calculation was made. Some positive welfare impact might be expected for the arable sector (due to the increased soy price). It can be guessed from results discussed before that the welfare impact to consumers will be negligible, however, since feed costs and livestock product prices were hardly affected.

The decomposition of welfare effects in Table 6.26 does not include a column on the welfare impact of related industries, such as the crushing industry, slaughtering houses, the dairy processing industry, the food processing industry, etc. For some of these sectors the impacts on welfare (profits or producer surplus) could be determined. In all cases except for the crushing sector, however, these impacts were very minor. There are two main reasons for this. First, the CAPRI tool used for the EU livestock sector impact assessment has no detailed representation of non-agricultural sectors (the dairy and crushing industry being two exceptions). In general the (other) processing (or distribution, packaging, transportation and handlings) sectors operate at a fixed margin[54]. Second, even when this would not be the case and welfare impacts could take place, in most cases minor welfare effects on these related industries are likely. As became clear from the results of the analysis of feed supply shocks, the volume of livestock consumption only slightly adjusts, which implies that the activity of dairy processing and slaughtering houses, for example, is not, or only marginally affected. For that reason the welfare effects will also be small. When approximating the impacts on the profits of the related industries by applying the rule that a certain percentage of their turnover would be profits, this would generate a positive welfare impact on average for the related industries. The reason is that, although there are small reductions in volume, the prices more than proportionally increase, and thus profits[55] will then do so as well.

The related industry which will be affected hardest with supply disruptions is the EU crushing sector. For the RED soy scenario it was found that both the volume of beans to be crushed as well as the crushing margin declined by about 30%. This implies a reduction of about 50% to the earnings of the crushing industry. In case of the ORANGE soy scenario, the margin went down by about 5%, whereas the amount crushed slightly declined, implying a loss in earnings of about 5 per cent.

---

[54] This implies that the marginal costs are fixed. This translates into a flat marginal cost curve, with producer surplus being zero by definition. In other words these sectors are approximated to be operating at a zero profit condition.

[55] It was tried to use such a profit approximation, but to calibrate the profit conditions in a realistic way, taking into account the heterogeneity between (old and new) Member States has been went far beyond the scope of this project. For that reason it was decided not to further develop this route and avoid suggesting any artificial precision that could not be backed up by serious empirical evidence.

6.5 Concluding remarks and epilogue

The soy and maize supply disruption scenario analyses presented can only be regarded as a first detailed approximation of the economic implications of possible feed shortages in the EU due to asynchronous authorisation of GM soy and maize products. It does not, for example, cover the economic implications of the immediate or very short run impact of supply disruptions. Moreover, although checks have been done, there are remaining uncertainties with respect to the availability of feed substitutes and the evolution of meat production and consumption outside the EU.

The EU impact analysis shows plausible results for the replacement of the disrupted trade in soy supplies that could occur because of asynchronicity in the approval by the EU of GM events used elsewhere, accompanied by price increases for soy products and a considerable expansion of domestic cultivation of soy in the EU (although this would not be able to cover the protein delivered by displaced soymeal imports), other oilseeds (mainly rapeseed) and cereals.

The economic effects on the livestock farming sector are moderated by the finding that the farmers can pass on to consumers a significant part of cost increases they face due to the supply disruptions. This result is due to the observed price increases for meat and other livestock products (related to inelastic demand), effective border protection, and large substitution possibilities in feedstuff ingredients. The livestock sector is, however, in general not able to pass on the full costs of a supply disruption and has to accept negative changes in gross margin (which might even have a larger impact on real profits). In particular the intensive livestock sector (pigs, poultry) in a number of key EU production Member States could well experience large drops in farm income (as measured by gross margin).

Although in percentage terms the losses in gross margin (i.e. roughly varying between 0% and 15% for the RED scenario) might suggest the impacts to be limited, the final impacts on farm income can be significantly higher than this. Most likely this will be the case for 5 out of 8 of the EU-27's most important pork, eggs and broiler producing Member States. Moreover there is a distributional issue: in reality there will be a certain share of livestock farms performing above average and below average. This implies that an important fraction of the intensive livestock farms (i.e. the lower than average performing part of the farm size distribution) may potentially face significant income losses depending on the seriousness of the feedstuff supply disruption occurring.

As was shown in the RED scenario, a scenario with the most serious impacts, the impact on meat production varied over member states as well as over the type of meat production. Both key producers as well as small producers are impacted. The impacts on key producers (Belgium, UK, Italy) have significant impacts on the EU's total supply of livestock products, But also for Member States, that do not play a role as a key producer within the EU, at the national level can be seriously impacted. Notable examples were Portugal, Czech Republic, Estonia and Latvia.

As regards the overall welfare impacts, the total impacts on agriculture are limited. This result is partly due to two counteracting forces: the arable sector is gaining and the livestock sector is losing from a feedstuff supply disruption. In the end it is in particular the consumer who loses the most welfare. In the worst case scenario considered (RED soy scenario), the (annual) loss to the consumers in the EU-27 amounts €10.5 billion. The welfare impacts on related industries are argued to be limited and could even be positive (at least when profitability of these industries is a certain fixed fraction of their turnover). An important exception is the EU soybean crushing industry, which under the ORANGE soy and RED soy scenarios sees both the volumes of soybeans to be crushed and its margins decline. In the RED soy scenario the earnings of the crushing sector would nearly halved.

As was discussed in the introduction of this chapter, the EU livestock sector impact assessment relies on a tool (CAPRI model), which compares equilibrium states before and after a supply disruption shock. Thereby it presumes a full settlement of adjustment processes (medium to long run impact analysis). However, the transition process from one equilibrium state to another (short run evolution of markets and prices) is not taken into account. Insight in short run impacts has been derived from the T-J trade impact analyses, for which a tool generating short run impacts is used.

As is illustrated by the projected short and long run effects of a feedstuff supply disruption, in the short run price increases can be substantially higher than they are likely to be in the long run. As this could not be demonstrated by the impact assessment tools used in this study, it should be kept in mind that the immediate effects of a supply disruption might be more severe than the results found from our analysis. To our knowledge there are currently no published studies which provide further insight into the immediate impacts of a supply disruption, although some research is underway (cf. Burger et al. (in preparation)). In this study no attempt has been (or could be) made to fill this gap. What is relevant from our results is to recognize that immediate and short run impacts, just because they can be so extreme, can have dynamic and short run effects on the livestock sector that are difficult to capture in the current analysis. For example, extreme cost increases might create immediate liquidity problems, especially for highly indebted farmers, which could affect their short run economic viability and their possibility to adjust to the new circumstances, although in the long run their viability would be not problematic. These dynamic and financial aspects may generate structural impacts on the livestock sector, for example because some farms will exit the sector in response to a supply disruption, whereas others will try to rapidly increase their scale. These qualifications should be kept in mind and may deserve further attention in another study.

7 Conclusions of the study

Peter Nowicki

The concluding chapter of this study is organised in five parts. The first part gives the main results of the study. The second part presents the main findings. The third part is a discussion of the implications of the findings of the study, which leads to a fourth part giving suggestions for potential policy adjustments for responding to the possible impacts that the disruption in the imports of maize and soybeans, and their derived products, for use in livestock feed could have in the EU. The last part presents the limitations of this study.

1. Main Results

Feasibility and potential costs of segregation of EU authorized from unauthorized GM events faced by trading partners

The critical factor concerning a possible disruption in the supply of imported livestock feedstuffs, in the form of soy and maize, is the degree of risk that GM feed supplies may be prohibited from entry to the EU. Past incidents are one guide to understand this factor (e.g. Hercules maize, L601 rice). However, as the number of GM events available is increasing rapidly, so is the complexity in understanding the feasibility for segregation of EU approved and non-approved GM material. In the past, the segregation capacity in many supplier countries was not a limiting factor, as only GM events approved by the EU were available commercially. This is not necessarily the case any longer, and therefore the possibilities for segregation at the level of trading partners (exporting countries to the EU) have become a matter of concern.

This study suggests that the logistical capacity of segregation in the main exporting countries to the EU, as far as infrastructure logistic are concerned, is not able to cope with the requirement of segregating GM material that is EU authorized from unauthorized. This result is to a large degree due to the circumstances of an increasing variety of GM plant material. Traders are therefore confronted with an increasing risk of shipments possibly containing *trace amounts* of EU unapproved GM material that might be detected upon arrival in the EU. As example, the LLP risk concerning maize gluten feed has already resulted in exports from the USA to the EU having virtually ceased by 2008. As traders are not willing to take the risk of losing considerable amounts of money, even if the probability of LLP were low, trade of maize and soy between the EU and North and South American sources may cease by 2020.

Costs of segregation of EU unauthorized GM plant material in exporting countries are difficult to isolate. However, an estimation based on available data of the traditional identity preservation programmes (GM separated from non-GM) will give an idea of the order of magnitude. The current producer premiums for *non-GMO* soy and maize have more than quadrupled in the USA from 2000-2009.

Substitution possibilities for feedstuff imports

Animal feed, which includes compound feeds and feed material, represents the main input into livestock sector. Within the EU, about 468 million metric tons of feed are consumed by livestock each year (FEFAC, 2009). These feed materials mostly consist of roughages (228 million metric tons) which are grown and used on the farm of origin. The rest (240 million metric tons) includes cereals grown and used on the farm of origin (51 million metric tons) and feed purchased by livestock producers to supplement their own feed resources. In the dairy sector, roughage is the main feed ingredient, while in other sectors, a large amount of compound feed is used (Burger et al., in preparation).

The substitution options such as changing import of raw materials, changing feed production in the EU, adapting the number of animals and changing feed composition differ over the short run (1-2 years) and the long run (5 years or more). In the short run, the price impacts for substitutes are expected to be larger than in the long run due to difficulties to adapt the production systems for substitutes as well as to change the supply flows of substitutes. Therefore, some adjustment may be required in livestock numbers as well as in livestock feed compositions to cope with the short term and long term effects of feed trade disruptions.

The effects on trade in the case of disruption in supplies to the EU because of asynchronous GMO approvals in the near future (horizon 2012)

In the event of a disruption in the supply of maize from the USA to the EU, only small amounts of maize would be involved, meaning practically no impact on EU supplies and prices. In the event of a disruption in the supply of maize to the EU from Argentina, Brazil and USA, 1.8 million metric tons of maize would no longer be available to the EU. This would result in a 4.7% increase in the price of maize imported to the EU from the world market. With a larger than average annual demand by the EU for maize, as observed in the marketing year 2007/08, the price increase would be 23.6%.

In the event of a disruption in the supply of soybeans and derived products from the USA to the EU, an estimated shortage of 3.5 million metric tons would be provided by Brazil. Given the dynamics of shifting trade patterns, the resulting increase in prices for imported soybeans to the EU would be 0.6%, and for soymeal 0.3%. In the case that the EU would lose soybean imports from Argentina, Brazil and the USA simultaneously, this would involve a shortage of some 15 million metric tons of soybeans. EU soybean production could increase by about 0.5 million tons within the time span of one harvesting period. Another 7 million metric tons could come from other exporting sources (principally Ukraine in Eastern Europe and Paraguay in South America). However, total supplies to the EU would decline by 7.5 million metric tons. If there were to be a loss soymeal imports to the EU from Argentina, Brazil and the USA simultaneously, this would represent a loss for the EU of 20 million metric tons of soymeal from these three countries. The overall short-term price increase would be in the order of 220% for soybeans and 210% for soymeal.

In the case of the loss of soybeans and soymeal imports from all the current major suppliers, the calculated result would cause major changes in global trade patterns. Accordingly, prices increases would be significantly higher than those calculated in the above-mentioned scenarios and would trigger much more significant adjustments to be made on the demand side within the EU.

Impact on the competitiveness of the EU livestock sector and welfare effects if trade disruptions are to occur in the long run (horizon 2020)

The competitiveness of the EU livestock sector is reflected in gross margins of livestock farmers. In the worst case to be envisaged for the EU livestock sector, which is the disruption of soybean and soymeal imports from all the major suppliers, gross margins would decrease in the long run by 3% for the dairy sector, by 16% for beef production, by 14% for pig fattening and by 7% for poultry meat production. These figures are a reflection of the relative importance of feed in total costs of production and the capacity of the livestock farmer to increase the total price – including gross margin – per livestock product at the farm gate. Profits could decrease by € 1.2 billion for the dairy sector, by € 3 billion for the beef sector, by € 1 billion for the pork meat sector, and by € 380 million for the poultry meat sector. The net agricultural sector income would be € 500 million, however, which reflects the expansion in arable production to cover part of the loss of soybeans and soymeal imported to the EU.

In this worst case situation, there would be shifts in the levels of livestock production among different Member States with relatively little change in livestock production of EU-15[56] as a whole, a slight decrease in the beef, dairy and pig sectors within the EU-10[57], and a an increase on the order of 2-3% for the beef, dairy and poultry sectors in Bulgaria and Romania. In terms of overall economic welfare effects in the EU, the effects on livestock farmers, arable farmers, and consumers would differ. To the degree that livestock farmers would be able pass on the major part of the added feed costs to consumers, the latter would pay an additional € 10.5 billion annually for meat and livestock-based products. Assuming possibilities for substitution by domestic feed production, EU arable farmers would benefit. The total cost to the economy would be € 9.6 billion. In as far as EU livestock producers face are exposed to global competition, possibilities for passing on increasing costs to consumers would diminish, which implies that the costs squeeze stays largely on the side of the farm sector. As a result, disruptions in feed supply and result feed price increases would severely damage the competitiveness of EU livestock production.

2. Main Findings

The main findings of the study are as follows:

- Based on the analytical framework, structural responses to asynchronicity – and given zero tolerance – are: (a) changes in trade patterns, (b) substitution of feed ingredients in feed rations (re-optimization subject to animal specific nutritional requirements) and (c) adjustments in primary production (land use adjustments within and outside the EU).

- There is, however, only a limited possibility to replace livestock feedstuffs by restructuring of trade patterns, particularly because segregation of supplies of approved events does not seem possible. Hence, asynchronicity in GMO approvals between the EU and exporting countries will continue to result in trade disruptions.

---

[56] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

[57] Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

Segregation

- The feasibility of consistently segregating EU approved from EU unapproved GM maize and soybeans in exporting countries was examined through a number of detailed country studies. Extensive supply chain analysis revealed that:
    - global maize and soybean production and exports are concentrated in just a few countries, most of which are GMO adopters;
    - the number of new GMOs authorized outside the EU is rapidly increasing in both maize and soybeans;
    - production of conventional and GM maize and soybeans overlap geographically;
    - storage, processing and distribution of conventional and GM maize and soybeans occurs through a limited and shared infrastructure built to maximize throughput and efficiency.
- All of these findings, in turn, imply that commingling and aggregation of maize and soybeans throughout the supply chain is likely, making guaranteed segregation of continuous supplies to the EU difficult.
- Segregation programs depend on prevention (supply chain controls) and remediation (testing and redirection of non-conforming grain). Because of continuous commingling and aggregation, the rate of grain diffusion throughout the supply chain is expected to be high. High grain diffusion rates are confirmed through case studies of extensive testing programs both with and without segregation in place. The results suggest that LLP of non-conforming grain in segregated supply chains is likely and the chances of failures are therefore high.
- The study also shows that segregation of approved from unapproved GMOs is further limited by the inability to test for some unapproved events quickly and in cost-effective ways at multiple critical points in the supply chain. Hence, remediation is also incomplete. Imperfect prevention and remediation procedures along with zero tolerance, in turn, imply high segregation and failure costs.
- The study finds that (a) high costs of segregation, (b) testing and analytical uncertainty and (c) high failure risks and costs will lead economic agents (producers, traders, processors) to avoid segregation. Given zero tolerance for EU unapproved GMOs, asynchronous GMO approvals result in major risks of trade disruption.

Short Term Changes in Trade and Price Impacts

- A number of plausible disruptions in the EU trade of maize, soybeans and soybean products were examined through spatial equilibrium analysis. The analysis revealed that disruptions in the bilateral trade flows between the EU and major exporters could would result in adaptations in global trade. EU imports could shift, at least in part, to non-traditional suppliers. At the same time, EU demand decreases (due to reductions in the size of livestock, changes in livestock diets, and substitution by alternative feedstuffs); EU domestic supplies of protein feed increase; crushing activity inside the EU declines; and EU maize, soybean and soybean product prices increase.

- A number of factors are found to influence the scope of these price and supply reactions, which includes the EU's import levels, its share in global exports, market developments in other countries, the relative costs of processing and transporting, the location of processing capacity, trade policies, and others.
- The EU is a major producer of maize and almost self-sufficient. EU maize imports are therefore limited and price increases due to asynchrony are found to vary between 5% (for a year of low imports) to 23% (year of higher imports).
- EU soybeans/soymeal imports are very high, supplies to the world market are dominated by USA, Brazil and Argentina and supplies from alternative suppliers are limited. When trade disruptions occur between the EU and the USA, price impacts are in the order of 25%. With trade disruptions involving three or more of the major exporters, the supplies to the EU are severely curtailed and prices of soybeans and soy meal increase by 210% or more over the short run (one to two years).
- The substitution options such as changing import of raw materials, changing feed production in the EU, adapting the number of animals and changing feed composition differ over the short run (1-2 years) and the long run (5 years or more).
- In the short run, the price impacts will be larger due to difficulties to adapt the production systems and limited availability of substitutes. This will result in in reduced livestock numbers in the EU, with some mitigation offered by changes in livestock feed compositions.

Long run substitutions in rations and feedstuffs used

- In the long run, there may be more possibilities for substitution within the EU for imported maize and soy. Where these possibilities do not exist, reductions in the number of animals will be unavoidable. Substitution could be imagined by growing or importing more rapeseeds, peas, and other substitutes, or using industrial by-products in higher quantities. Taking into account some time-lags in the adaptation, price impacts will be smaller in the long run than in the short run.
- In two of the scenarios analysed, the supply disruptions include a massive displacement of imported soybeans and soybean products away from the EU market. With the current pace of GMO approvals in the EU, such an outcome is most probable in the long term (2020), while in the short term (2012) this probability is lower, while a severe crisis due the temporary unavailability feed imports might arise occasionally.
- For understanding the medium to long run equilibrium, the availability of substitution options, the inelastic demand for livestock products, and the presence of effective border protection for meat are decisive. Border protection would ensure that the reduction in domestic livestock supply drives prices up, thereby improving the revenues the livestock sector who effectively pass on increasing feed costs to the consumers.

- With adjustments in the livestock sector being limited, the latter would bear the brunt of the adjustments that have to take place. In the feed markets substantial price changes might be observed (in particular for soybeans, soy meal and maize), driving a range of complex substitution processes.

- Substitution possibilities, the share of feed costs in total costs, and the share of total costs in total revenues determine the impact of increasing feed prices on the final product value. Large price increases of for feed stuff (e.g. 95% long run soybean price increase in case of the worst case scenario) ‘translate’ into relatively modest price increase for livestock products that will roughly vary between 5% and 15%.

- Given the inelastic demand for livestock products, in the worst case scenario (assumed for 2020) the demand for livestock products declines, but less than proportionally (e.g. between 2% and 10%). It should be noted that the CAPRI model – which is the principal tool used for the analysis of livestock products – has a comparative static nature, comparing different equilibrium states, while not giving information regarding the adjustment and transition process. Thus, nothing can be said about effects faced in the short run (one to two years). In the worst case of a loss of soy imports to the EU from all major suppliers, the short run price increase might be twice as large as the long run price increase.

- As shown by the T-J modelling analysis (which can be argued to reflect a more short run nature with a lower amount of substitution possibilities) as well as from the assessment of the short term (2012) scenario of temporary shortages of feedstuff supplies, short run impacts can be very substantial, with the livestock sector suffering from extreme price increases.

- The modelling analysis suggests that the livestock sector can pass on a substantial part of the increase in feed costs to the consumer of the livestock products. Nevertheless, also gross margins were found to decline due to the increase in costs. Depending on the supply disruption scenario, type of livestock production (especially in pigs and poultry), and Member State concerned (including key producers such as Denmark, France, Germany, Netherlands and the United Kingdom), substantial losses in farm income could not be excluded.

- In as far as feed price increases can be passed on to the consumer, the latter pay eventually the cost for the supply disruption of maize and soybean brought about by asynchronous GMO authorisation, in the order of €10.5 billion per year.

3. Implications of study findings

Former studies on the consequences of low level presence of EU unauthorised GM events in imported livestock feed have stressed the very large price increases for feed material which would destabilise the livestock sector, leading to a loss of competitiveness domestically and abroad. Although our study concludes that trade disruption in GM feed material coming from current major suppliers would be increasingly of a structural character and would soon become inevitable, the market reality would also set in motion an adjustment process which could be successful if not all sources of supplies are lost at once.

Part of the impending structural breakdown in trade has to do with the current “zero tolerance” threshold which restricts importing EU unapproved GM material, and this can be dealt with by regulation. Production adjustment within the EU is another matter, and can be guided by policy as well as broad knowledge within the livestock sector of the actual risk of supply disruption. The trade disruptions foreseen in the scenarios elaborated within this study clearly show that in the case of a severe disruption developing, it would mean that there would not be enough supplies of feed material to satisfy current demand. Economic theory simply states that in the absence of supply, demand for feed must decrease. The only immediate adjustment possible is to reduce the livestock herd and to progressively restructure around more extensive livestock management – where possible – and to shift the mix of feed ingredients used; this will require a response of arable crop producers in function of prices for various crops. The ultimate situation is that feed prices will rise, and that most of the increase will be passed on to the consumer because – despite feed costs increases – tariffs continue to protect the livestock sector from import competition. Substitution is also possible, however, over time, contributing to adjustment of the sector, and this is one of the important findings of this study. Although a transition period would see some livestock producers cease farming, others would be able to reduce activities while optimising their operations.

Part of the process is the initial reduction in livestock numbers mentioned before; during this period there would be an excess of meat available, so the consumer would not necessarily be affected in the beginning but livestock farmers will; price levels would depend on how much of initial increase in meat supplies can be equalized over time through storage. Afterwards, the restructuring of the livestock activities would be accompanied by a price rise when less animals would be available, but this would be tempered during the period when livestock products are released from storage. The cycle for animal products is differential: for poultry it is on the order of a few months, for pigs it is 1.5 years and for beef it is about 3 years; dairy is a high added value activity and higher prices for feed would be more easily absorbed by higher prices because of the global demand. The point to be made, nevertheless, is that each livestock activity would react differently.

Eventually higher prices will be passed on to the consumer as livestock production comes to a new equilibrium with the market, although at a level between 2 to 20 per cent lower depending on the type of activity. Up- and downstream sectors would also need to adjust their capacity according to this lower product volume. The consumers would be left with higher food prices, at an estimated increase in the total food bill by 10.5 billion euro per year.

It should be noted here that the competitiveness of some parts of the livestock industry already benefits from tariff measures that in any case are subject to review within the international framework of the World Trade Organisation.

What this study highlights is that adjustment processes are possible, that they will take time, and that while parts of the livestock sector are hurt through lower margins or lower demand for capacity others remain competitive as long as the industry continues to be protected through relevant tariffs.

4. Potential Policy Adjustments

The choice of farmers around the world to plant GM crops is based on perceived benefits from increased net revenues resulting from increasing yields while reducing the costs of production. In addition, the demand for maize and soybean, and their derived products, is growing rapidly around the world, especially in China. At the same time the relative importance of the EU market – which has a stable demand over the period considered in this study – inevitably diminishes. This will discourage efforts by producers and traders in exporting countries to invest in segregating EU approved from non-approved GM material and to continue trading with the EU, considering current "zero tolerance" for EU unauthorized GM events.

One possibility to avoid the situation above from occurring is to speed up the authorisation processes for novel GM events, especially with the likely proliferation of stacked traits (a single solution for a multitude of production related risks or benefits). In this context, it is necessary to additionally take into account the increasing number of countries which are embarking on the development of GM events, and which will be submitting applications to the EU for authorisation of the novel events.

A second possibility is to introduce a practical tolerance threshold for EU unauthorized GM events that would allow LLP in shipments to the EU. In this regard, harmonisation of rules regarding LLP at the global level would be an advantage in view of minimising potential trade frictions.

A third possibility is to anticipate the consequences of potential shortages would be to explore the possibilities for increasing the range of feed ingredients. This could benefit from an applied research programme within the EU.

5. Limitations of this study

The limitations of the study reside in two points. First, the use of the models beyond their normal conditions. Second, the fact that the transition between the beginning of a structural feed supply shortage and the new equilibrium in EU livestock composition (taking into account changes in the nature and cost of feed ingredients) has only been briefly explored within the study. This last point merits a full investigation when an appropriate methodological capacity has been developed and peer-reviewed by the scientific community.

8 References

Abate, A.N. and M. Gomez (1984). “Substitution of fingers millet (*Eleusine coracana*) and bulrush millet (*Pennisetum typhoides*) for maize in broiler feed”, *Animal Feed Science and Technology*, 10, pp. 291-299.

Abud S., de Souza P.I.M., Vianna .GR., Leonardecz E., Moreira C.T., Faleiro F.G., Junior J.N., Monteiro, .P, Rech E.L., Aragao F.J.L. (2007) Gene flow from transgenic to nontransgenic soybean plants in the Cerrado region of Brazil. *Genetics and Molecular Research* 6: 445-452.

Acworth, W., A. Yainshet and R. Curtotti (2008). *Economic impacts of crops in Australia*. ABARE research report 08.4, www.abare.gov.au.

ADAS, 2008, *What is the potential to replace imported soya, maize and maize by-products with other feeds in livestock diets?*, paper for Defra, available from
http://www.defra.gov.uk/environment/quality/gm/crops/documents/foodmatters-otherfeeds-1308.pdf
(accessed March, 4, 2010).

Adeyemi, O.A and Familade, F.O (2003), “Replacement of maize by rumen filtrate fermented corn-cob in layer diets”, *Bioresource Technology*, 90, pp. 221-224.

Agwunobi, L.N.(1999), “Dioscorea alata (Water yam) as a replacement for maize in diets for laying hens”, *Tropical Animal Health and Production*, 31, pp. 391-396.

Aramyan, L.H., C.P.A. van Wagenberg and G.B.C. Backus (2009). *EU policy on GM soy: Tolerance threshold and asynchronous approval*. LEI Report 2009-052, LEI Wageningen UR, Den Haag, the Netherlands.

ASA (2010). *Adoption of Biotech-enhanced Soybean Seedstock 1997-2007*. American Soybean Association, USA, http://www.soystats.com/2008/Default-frames.htm (accessed 9 February 2010).

Backus, G.B.C., P. Berkhout, D.J.F. Eaton, L. Franke, A.J. de Kleijn, B. Lotz, E.M. van Mil, P. Roza and W. Uffelmann (2008). EU policy on GMOs: a quick scan of the economic consequences. *LEI Report* **2008-070**. The Hague: Wageningen University and Research Centre.

Batz, F. J. (1999). "The influence of technology characteristics on the rate and speed of adoption." *Agricultural Economics* 21(2), pp. 121-130.

Blom, J.C. (1995). *Een geregionaliseerd graan- en mengvoedergrondstoffenmarkt model voor de EU-12*. PhD-thesis Wageningen Agricultural University, Wageningen, the Netherlands.

Bondt, N., van Wagenberg, C., Bakker, R., Janssens, B. (2009). “Biomassa voor veevoer
en energie Scenarioanalyse van verschuiving in grondstoffengebruik”, Rapport 2009-048, LEI, The Hague.

Brand T.S., R.C. Olckers and J.P. van der Merwe (1995), “Triticale (Tritico secale) as substitute for maize in pig diets”, *Animal Feed Science and Technology*, 53(3), pp. 345-352.

Brand, T. and J.P. van der Merwe (1996), “Naked oats (Avena nuda) as a substitute for maize in diets for weanling and grower-finisher pigs”, *Animal Feed Science and Technology*, 57, pp.139-147.

Burger, C.P.J., D.M. Jansen, P.M.F. Quist-Wessel & B. Rutgers (in preparation). Effects of multiple calamities on the European food system. Wageningen, Plant Research International B.V.

Blom, J.C. (1995). *Een geregionaliseerd graan- en mengvoedergrondstoffenmarkt model voor de EU-12*. PhD-thesis Wageningen Agricultural University, Wageningen, the Netherlands.

Britz, W. (2005) CAPRI Modelling System Documentation, University of Bonn:
http://www.agp.unibonn.de/agpo/rsrch/capri/capri-documentation.pdf.

Britz, W. and Heckelei, T. (1999): Calibration of feed requirements and price determination of feed in CAPRI,University of Bonn, CAPRI Working paper 99-06: http://www.agp.unibonn.de/agpo/rsrch/capri/wrkpap_e.htm.

Brooks, G. (2001), The EU animals feed sector: protein ingredients use and implications of the ban on use of meat and bone meal. Brookes West, Elham, Canterbury, UK

Bullock D.S., Desquilbet M. (2002) The Economics of non-GMO segregation and identity preservation, Food Policy 27, 81-99

Burger, C.P.J., D.M. Jansen, P.M.F. Quist-Wessel and B. Rutgers (in preparation) *Effects of multiple calamities on the European food system*, Development Economic Groups and Plant Research International, Wageningen UR, Wageningen

Carter, C., D. Berwald and A. Loyns. 2005. *The Economics of Genetically Modified Wheat.* Toronto, University of Toronto, Centre for Public Management.

Chen, C., B. McCarl, and C. Chang, "Estimating the Impacts of Government Interventions in the International Rice Market," *Canadian Journal of Agricultural Economics*, 54(2006):81-100.

Chung, C. and J. Pettigrew (1998). "Economics of Soybean Biotechnology in the Livestock Industry", *International Food and Agribusiness Management Review*, 1(3), pp. 373-385.

Christofer, G. I., Offfiong, S. and Idiong, I. C. (2007), "Effect of the replacement of maize with wheat offal in broiler finisher diets on growth performance and feed cost'", *Journal of Central European Agriculture*, 8, pp. 33-38.

Christoffoleti PJ, Galli AJB, Carvalho SJP, Moreira MS, Nicolai M, Foloni LL, Martins BAB, Ribeiro DN (2008) Glyphosate sustainability in South American cropping systems. Pest Management Science 64: 422-427.

Coléno, 2008 "Simulation and evaluation of GM and non-GM segregation management strategies among European grain merchants." *Journal of Food Engineering* 88(3), pp. 306-314.

CVB (1997) *Verkorte Tabel 1997: Voedernormen landbouwhuisdieren en voederwaarde veevoeders*. CVB reeks No.22, Lelystad, Centraal Veevoeder Bureau

Daems, W., M. Demont, F. Muška, J. Soukup and E. Tollens (2007). "Potential impact of biotechnology in Eastern Europe: Genetically modified maize, sugar beet and oilseed rape in the Czech Republic", Working Paper, n° 93, Katholieke Universiteit Leuven, Leuven.

Dahl, B.L., & Wilson, W.W. (2002). *The logistical costs of marketing identity preserved wheat* (Report No. 495). Fargo, ND: North Dakota State University Department of Agribusiness and Applied Economics.

Davison, J. (2010): GM plants: Science, politics and EC regulations. Plant Science 178, 94-98.

De Boer, H.C., Zom, R.L.G., and Meijer, G.A.L.(2006), "Haalbaarheid vervanging soja in Nederlandse melkveerantsoenen", Rapport 04, Animal Science Group, Wageningen UR.

DEFRA/FSA (2009). *GM crops and foods: Follow-up to the Food Matters report*. DEFRA and FSA. http://www.defra.gov.uk/environment/gm/crops/index.htm.

Desquilbet, M., S. Lemarié, and F. Levert (2001). Potential adoption of GM rapeseed in France, effects on revenues of farmers and upstream companies: an *ex ante* evaluation, Proceedings of the firth International Conference on Biotechnology, Science and Modern Agriculture: a New Industry at the Dawn of the Century, Ravello (Italy), June 2001. Available from: www.inra.fr. (09-09-08).

Dimitrijevic, D., 2007, Serbia FAIRS Country Report 2007, USDA Foreign Agricultural Service GAIN Report.

Dimitrijevic, D., 2009, Serbia Grain and Feed Annual Report 2009, USDA Foreign Agricultural Service GAIN Report.

Dutch Soy Coalition (2009). Strategies for reducing the negative impacts of soy production: Replacing soy in animal feed. Factsheet 3. Availabel from http://commodityplatform.org/wp/wp-content/uploads/2009/12/factsheet_3_replacing-soy-in-animal-feed_final.pdf (Accessed 4 March 2010).

EC (2007). "Economic impact of unapproved GMOs on EU feed import and livestock production. DG AGRI report. http://ec.europa.eu/agriculture/publi/reports/gmo/economic_impact_unapproved_gmos_en.pdf

European Commission (2010a). Rules on GMOs in the EU – Authorisation. http://ec.europa.eu/food/food/biotechnology/gmo_authorisation_en.htm, accessed at May 17, 2010.

European Commission (2010b). Community register of genetically modified food and feed. http://ec.europa.eu/food/dyna/gm_register/index_en.cfm, accessed at May 17, 2010.

FAOSTAT, 2010. http://faostat.fao.org/default.aspx Accessed May 2010

Fawcett R, Towery D (2002) Conservation tillage and plant biotechnology: how new technologies can improve the environment by reducing the need to plow. Conservation Technology Information Center. West Lafayette, IN, USA.\

FeedMod User's Guide (2009). Modelling of Feed Consumption in the European Union. November 12.

FEFAC (2009). *Feed & Food; Statistical Yearbook 2008*. European feed manufacturers federation, Brussels, Belgium. www.fefac.eu

FEFAC (2010). *Compound Feed Production (1989-2009)*. European feed manufacturers federation, Brussels, Belgium. http://www.fefac.org/file.xls?FileID=15062 (accessed 9 February 2010).

Fernandez-Cornejo, J., C. Klotz-Ingram, and S. Jans (2002). "Farm-Level Effects of Adopting Herbicide-Tolerant Soybeans in the U.S.A." *Journal of Agricultural and Applied Economics* 34(1), pp. 149-163.

Fiks-van Niekerk, T.G.C.M. and B.F.J., Reuvekamp, (2009), "Options to realise a 100% organic feed for laying hens", In: Proceedings of the 8th European Symposium on Poultry Welfare, Cervia, Italy, May ,18-22.

Fischer Boel, M. (2009). GMOs: letting the voice of science speak. Policy Dialogue at "European Policy Centre", Brussels, SPEECH/09/474.

Flaskerud, G. 2003. Brazil's soybean production and impact. Fargo: North Dakota Extension Service, NDSU.

Food and Agriculture Organization of the United Nations, FAOSTAT, TRADESTAT http://faostat.fao.org/site/406/default.aspx

Food and Agricultural Policy Research Institute "Elasticity Database" http://www.fapri.iastate.edu/tools/elasticity.aspx

Franke, A.C., F.M. Greco, M.Y. Noordam, P. Roza, D.J.F. Eaton, P.S. Bindraban and L.A.P. Lotz (2009). *The institutional and legal environment for GM soy in Brazil*. Rapport Plant Research International 297, Plant Research International, Wageningen, the Netherlands.

Froidmont, E. and N. Bartiaux-Thill (2004). "Suitability of lupin and pea seeds as a substitute for soymeal in high-producing dairy cow feed", *Animal Research*, 53, pp. 475-487.

GMO Compass (2008). Crops. Rapeseed.

http://www.gmo-compass.org/eng/grocery_shopping/crops/21.genetically_modified_rapeseed.html (accessed July 9, 2010)

Gómez-Barbero, M., Berbel J, E. Rodríguez-Cerezo (2008). Adoption and performance of the first GM Global Trade Information Services “Global Trade Atlas” (http://www.gtis.com/english/GTIS_revisit.html)

Gomez-Barbero et al., 2008. Gómez-Barbero, M., and E. Rodríguez-Cerezo (2007). GM crops in EU Agriculture. Available from: http://bio4eu.jrc.es/documents/FINALGMcropsintheEUBIO4EU.pdf. (09-09-08).

Gómez-Barbero, M., Berbel J, E. Rodríguez-Cerezo (2008). Adoption and performance of the first GM crop introduced in EU agriculture: Bt maize in Spain. JRC Scientific and Technical Reports. EUR 22778.

Gouse, M., J. Piesse, C. Thirtle and C. Poulton (2009). “Assessing the Performance of GM Maize Amongst Smallholders in KwaZulu-Natal, South Africa”, *AgBioForum*, 12(1), pp.78-89.

Hasha, G. (2002) *Livestock feeding and feed imports in the European Union –A decade of change*. Washington DC, ERS, USDA, FDS-0602-01.

Hurburgh, C.R. “Identification and Segregation of High-value Soybeans at a Country Elevator.” *Journal of American Oil-Chemists Society*, 71, 1073-1078, 1994.

Huygen, I., Veeman, M., & Lerohl, M. (2004). Cost implications of alternative GM tolerance levels: Non-genetically modified wheat in western Canada. *AgBioForum*, *6*(4), 169-177.

James, C. (2007). *Global Status of Commercialized Biotech/GM Crops: 2007*. ISAAA Brief No. 37, ISAAA, Ithaca, NY, USA.

James C, 2010. Global status of commercialized Biotech/GM crops: 2009. Brief 41 ISAAA.

Jaroszewska, 2007 Ukraine

Jongeneel, R. (2000). *The EU's grains, oilseeds, livestock and feed related market complex: welfare, measurement, modeling and policy analysis*. PhD Dissertation, University of Wageningen, Wageningen, the Netherlands.

Kalaitzandonakes, N., R. Maltsbarger, and J. Barnes. 2001. Global identity preservation costs in agricultural supply chains, *Canadian Journal of Agricultural Economics* 49(1): 605-15.

Kalaitzandonakes N.G., Magnier A. (2004) Biotech labelling standards and compliance costs in seed production. Choices (2nd Quarter), 1-9

Kalaitzandonakes, N. “Cartagena Protocol: A New Trade Barrier?” *Regulation*, 29(2): 18-25, 2006.

Kamp, J., S. van Berkum, H. van laar, W. Sukkel, R Timmer and M. van der Voort (2008). “Perspectieven van sojavervanging in voer. Op zoek naar Europese alternatieven voor soja”, PPO report No 325119600, Wageningen, The Netherlands

Kaspersson, E., Rabinowicz, E. and Schwaag Serger, S. 2002. EU milk policy after enlargement – competitiveness and politics in four candidate countries. Lund: Swedish Institute for Food and Agricultural Economics.

Khalifa, N.A, Elzubeir, E.A., and Mustafa E.A.(1994). “Use of sorghum gluten feed as a substitute for soyabean meal in layer diets”, *Animal Feed Science and Technology*, Vol. 48 (102), pp. 165-168

Kool, A., Blonk, H., Ponsioen, T., Vermeer, H., de Vries, J., Hoste, R., (2010), “Carbon footprints of conventional and organic pork. Assessment of the typical production system in the Netherlands, Denmark, England and Germany”, Blonk Milieu Advies BV., Gouda

Landblom, D.G., Harrold, R, L., Poland, W.W. Miller, K. (2001), “An evaluation of the replacement value of field peas for soymeal in sow lactation diets”, Annual report, Dickinson Research Extension Center, North Dakota State University. Retrieved February 26, 2010, from
http://www.ag.ndsu.nodak.edu/dikinso/research/2000/swine00b

Lin, W. W., W. Chambers and J. Harwood. 2000. Biotechnology: U.S. grain handlers look ahead. *Agricultural Outlook* (April): 29–34.

Louwaars N, Dons H, van Overwalle G, Raven H, Arundel A, Eaton D, Nelis A, 2009. Veredelde zaken. De toekomst van de plantenveredeling in het licht van ontwikkelingen in het octrooirecht en het kwekersrecht. CGN rapport 14, CGN/Stichting DLO, Wageningen.

Magnier, A., S. Konduru, N. Kalaitzandonakes (2009) Market and Welfare Effects of Trade Disruption from Unapproved Biotech Crops. (Theoretical economic model) Selected Paper preparesd for presentation at the Agricultural & Applied Economics Associaition’s 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, WI, USA, July 26-28, 2009.
http://ageconsearch.umn.edu/bitstream/49592/2/MSKTradeDis613331.pdf

Maltsbarger, R. and N. Kalaitzandonakes. 2000. Hidden costs in the IP supply chain. *Feedstuffs* 72 (36): 1–2.

Maslac, T., 2003, Serbia and Montenegro Biotechnology Regulations 2003, USDA Foreign Agricultural Service GAIN Report.

Maslac, T., 2005, Serbia Biotechnolgy Annual 2005, USDA Foreign Agricultural Service GAIN Report.

Maslac, T., 2009, Serbia Wheat and Corn Update, USDA Foreign Agricultural Service GAIN Report.

McKinzie, L., P.L. Paarlberg and I.P. Huerta (1986) “Estimating a Complete Matrix of Demand Elasticities for Feed Components using Pseudo Data: A Case Study of Dutch Compound Feeds,” *European Review of Agricultural Economics*, 13(1), pp. 21-42.

Meijl, Hans van, and Frank van Tongeren (2004), International diffusion of gains from biotechnology and the European Union’s Common Agricultural Policy, *Agricultural Economics*, 31, pp. 307-316.

Menrad K. G. (2009) Costs and benefits of segregation and traceability between GM and non-GM supply chains of final food products. Co-Extra. GM and Non GM Supply Chains” their co existence and traceability. Conference paper. June 5-9 2009 Paris, France.

Miranowski, J., H. Jensen, S. Batres-Marquez, and A. Ishdorj. “Product Differentitaion and Segregation in Agricultural Systems: Non-Genetically Modified and Specialty Corn and Soybean Crops in Iowa.” Center for Agricultural and Rural Development, Report 04-WP 354, Iowa State University, Ames, 2004.

NCPA, (2002). National Cottonseed Products Association. Cottonseed Feed Products Guide. http://www.cottonseed.com/publications/feedproductsguide.asp (accessed July 9, 2010)

Nelson, G.C., Josling, T., Bullock, D., Unnevehr, L., Rosegrant, M., & Hill, L. (1999). *The economics and politics of genetically modified organisms in agriculture: Implications for WTO 2000* (Bulletin 809). Urbana, IL: University of Illinois Office of Research Consumer and Environmental Science Department.

Nowicki, P., V. Goba, A. Knierim, H. van Meijl, M. Banse, B. Delbaere, J. Helming, P. Hunke, K. Jansson, T. Jansson, L. Jones-Walters, V. Mikos, C. Sattler, N. Schlaefke, I. Terluin and D. Verhoog (2009) *Scenar 2020-II – Update of Analysis of Prospects in the Scenar 2020 Study* – Contract No. 30–CE-0200286/00-21. European Commission, Directorate-General Agriculture and Rural Development, Brussels.

Paarlberg, P.L. (1979). *The Development of Linear Programming Models for the Dutch and British Swine and Broiler Industries*. FDCD Working Paper, Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture, USA.

Pérez Domínguez I. (2010) Calculation of the effects of increased demand for biofuel feedstocks on world agricultural markets, workshop on "The Effects of increased demand for Biofuels feedstocks on the world agricultural markets and areas", 10 February 2010, Ispra, Italy.

PDV (2007). *Veevoedertabel*. Product Board Animal feed, Den Haag, the Netherlands, http://www.pdv.nl/lmbinaries/pdv06-07_(3).pdf (accessed 9 February 2010).

Peeters, L. and Y. Surry (1997). "A review of the arts of estimating in the European Union price-responsiveness of feed demand", *Journal of Agricultura1 Economics*, 48(3), pp. 379-392.
Plato, G. and W. Chambers, 2004. How does structural change in the global soybean market affect the USA price? Washington DC, USDA OCS 04D-01.

Philippidis, G. (2010). "EU import restrictions on genetically modified feeds: impacts on Spanish, EU and global livestock sectors," *Spanish Journal Of Agricultural Research*, 8 (1), 3-17.

Quaim, M., and M. De Janvry (2003). "Genetically Modified Crops, Corporate Pricing Strategies and Farmers' Adoption: The Case of Bt Cotton in Argentina", *American Journal of Agricultural Economics*, 85 (4), pp. 814-828.

Quaim, M., and D. Zilberman (2003). "Yield effects of genetically modified crops in developing countries", *Science*, 299, pp. 900–902.

Samuelson, P., "Spatial Price Equilibrium and Linear Programming," *American Economic Review*, 42(1952):283-303.

Schaart JG, Visser RGF, 2009. Novel plant breeding techniques. Consequences of new genetic modification-based plant breeding techniques in comparison to conventional plant breeding. COGEM report, Commission Genetic Modification.

Sikka, S.S. (2007), "Effect of replacement of maize and rice bran with paddy on the growth performance and carcass traits of growing finishing pigs", *Livestock Research for Rural Development*, 19, Article #92. Retrieved February 26, 2010, from http://www.lrrd.org/lrrd19/7/sikk19092.htm

Smyth, S., & Phillips, P.W.B. (2001). *Identity-preserving production and marketing systems in the global agri-food market: Implications for Canada*. Saskatoon, Canada: University of Saskatchewan.

Sobolevsky, A., G. Moschini, and H. Lapan, "Genetically Modified Crops and Product Differentiation: Trade and Welfare Effects in the Soybean Complex," *American Journal of Agricultural Economics*, 87(2005):621-644.

Song et al., 2007. Market power and competitive analysis of China's soybean import market. Contributed paper presented for the International Agricultural Trade research Consortium (IATRC), July 8-9th, 2007, Beijing, China.

SoyStats (2010) Available online: http://www.soystats.com/2009/Default-frames.htm Accessed February 2010

Stanton, T.L., and S. LeValley (2006). *Feed composition for cattle and sheep*. Livestock series no. 1615, Colorado State University Extension, Fort Collins, Colorado, USA.

Stein, A.J. and E. Rodríguez-Cerezo (2009). The global pipeline of new GM crops: introduction to the database. *JRC Technical Note* **EUR 23810 EN**. Luxembourg: Office for Official Publications of the European Communities. http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=2199

Sundstrom, F.J., J. Williams, A. van Deynze and K.J. Bradford, 2002. Identity preservation of agricultural commodities. Davis,: University of California, Division of Agrouclture and Natural reources, (Agricultural Biotechnology in California Series, Pub. 8077).

Takayama, T., and G. Judge (1971), *Spatial and Temporal Price and Allocation Models*, Amsterdam: North-Holland Publishing..

Tallage (2010) Study on modelling of feed consumption in the European Union; Final Deliverable Study Report. EU study Tender No. AGRI-2008-EVAL-09.
http://ec.europa.eu/agriculture/analysis/external/feed/index_en.htm

Tukker A., Bausch-Goldbohm S., Verheijden M., de Koning A., Kleijn R., Wolf O. and Pérez Domínguez I (2009) Environmental Impacts of Diet Changes in the EU, JRC Scientific and technical report, EUR Number: 23783 EN, 6/2009
United Nations “Comtrade” http://comtrade.un.org/db/default.aspx

United States Department of Agriculture, *Embargoes, Surplus Disposal, and U.S. Agriculture*, Agricultural Economic Report 564, Economic Research Service: Washington, DC, 1986.

USDA-FAS (2010a). Grain: World Markets and Trade. Circular Series FOP 9–10, September 2010.

USDA-FAS (2010b). Oilseeds: World Markets and Trade. Circular Series FOP 9–10, September 2010.

U.S. Department of Agriculture, Foreign Agriculture Service, Production Supply and Distribution Database. http://www.fas.usda.gov/psdonline/

USA Dept of Energy, Energy Information Administration “Electricity Prices for Industry” (http://www.eia.doe.gov/emeu/international/elecprii.html)

USA Dept of Energy, Energy Information Administration “Natural Gas Prices for Industry” (http://www.eia.doe.gov/emeu/international/ngasprii.html)

U.S. Department of Labor, Bureau of Labor Statistics, “International Labor Comparisons” http://www.bls.gov/fls/chartbook.htm

van Wagenberg, C.P.A. (2009). *Economic consequences of EU-unapproved GM maize in USA soy; Estimates for the periode Octiber 2009 to March 2010*. Memorandum 09-071, LEI Wageningen UR, Den Haag, the Netherlands.

van de Wiel, C.C.M.; Groeneveld, R.M.W.; Dolstra, O.; Kok, E.J.; Scholtens, I.M.J.; Thissen, J.T.N.M.; Smulders, M.J.M.; Lotz, L.A.P. (2009) Pollen-mediated gene flow in maize tested for coexistence of GM and non-GM crops in the Netherlands: effect of isolation distances between fields. *NJAS Wageningen Journal of Life Sciences 56 (4). - p. 506 - 523.*

Webster, T.M. & Sosnoskie, M. (2010) Loss of glyphosate efficacy: a changing weed spectrum in Georgia cotton. *Weed Science*, 58, pp. 73-79.

Wilson, W., and B. Dahl. (2005) “Costs and Risks of Testing and Segregating Genetically Modified Wheat.” *Review of Agricultural Economics* 27(2):212-228, 2005.

Wilson, W., and Dahl, B. (2008) Costs and Risks of Conforming to EU Traceability Requirements: The Case of Hard Red Spring Wheat. *Agribusiness*, Vol. 24 (1) 85–101

Witzke P, Kempen M, Pérez Domínguez I, Jansson T, Sckokai P, Helming J, Heckelei T, Moro D, Tonini A and Fellmann T (2009) Regional Economic Analysis of the Abolition of the Milk Quota Regime in Europe, JRC Scientific and Technical Reports, Institute for Prospective Technological Studies, Seville, EUR 23961 EN, URL: http://ftp.jrc.es/EURdoc/JRC53116.pdf

World Agriculture Trade Simulation Model (WATSIM)
http://www.ilr1.uni-bonn.de/agpo/rsrch/watsim/databasewatsim02.xls

World Trade Organization “WTO Tariff Database” http://tariffdata.wto.org/