EU policy on GM soy

Tolerance threshold and asynchronic approval

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Importing soybean into the EU is going to become more difficult. The maximum delay in the EU approval process for GMOs compared to the US is one year. A two-year delay period can lead to problems for the supply of raw materials. This conclusion is not influenced by the chosen tolerance threshold level within the range 0.0-0.9%. When both Brazil and the EU have the same approval policy, supply problems are not expected.

Het invoeren van sojabonen in de EU gaat moeilijker worden. De maximale vertraging in het EU-goedkeuringsproces voor ggo's ten opzichte van de VS is één jaar. Een vertragingsperiode van twee jaar kan tot problemen met het aanbod van grondstoffen leiden. De gekozen tolerantiedrempel van 0,0 tot 0,9% heeft geen invloed op deze conclusie. Als Brazilië en de EU hetzelfde goedkeuringsbeleid hanteren, worden er geen problemen met het aanbod verwacht.

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Contents

Preface

The cultivation of genetically modified (GM) soy has seen a rapid growth since 1996, especially in North and South America. Over the last years there have been increasing difficulties with the EU import of protein rich (e.g. soy) GM feedstuffs from major exporting countries This is among other things caused by the lengthy procedure in the EU for the approval of new genetically modified organisms (GMOs). In contrast, the use of GM crops in the EU is rapidly increasing, as the EU livestock industry is highly dependent on the import of soybean products. These products are mainly sourced in countries where the cultivation of GM crops is widespread.

Over the last years there have been difficulties with the import of GM soy as a feedstuff from major exporting countries. This is caused by the asynchronous EU approval of GM crops and the operation of a zero tolerance threshold for the presence of GMOs not yet approved in the EU. The cultivation of GM soy crops is expected to grow, which might result in even more difficulties for the EU feed industry. The Dutch branch organisation for producers of animal feed - Nevedi - asked LEI Wageningen UR to assess this likelihood for various scenarios with different tolerance threshold levels and delays in EU approval of new GM soy varieties. The aim of this research is to assess the quantitative impact of the EU policy regarding GM soy on possible trade problems with the EU import of GM soy. To do so we analysed different scenarios with a stochastic computer based model of the soy supply chain.

The project was supervised by a steering committee with as members H.W.C.M. Flipsen (Nevedi), D. de Glint (Nevedi), P.J.M. Jansen (Vionfood), J.W.G.M. Swinkels (ZLTO), M.L. Vernooij (Dutch Ministry of Agriculture, Nature and Food Quality), J.B.F.C. van den Assum (Dutch Ministry of Agriculture, Nature and Food Quality), D.J. Kennes (Rabobank), J.A. Bijloo (Frieslandfoods), and A.H. Broekema (Royal Dutch Grain and Feed Trade Association). The authors wish to thank the steering committee for their useful comments during the inception of the report. The information given by a number of persons in

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Summary

The cultivation of genetically modified (GM) soy has seen a rapid growth since 1996, especially in North and South America. Over the last years there have been increasing difficulties with the EU import of soy from major exporting countries. This is among other things caused by the lengthy procedure in the EU for the approval of new genetically modified organisms (GMOs) in combination with a zero tolerance for traces of unapproved varieties. However, the EU livestock industry is highly dependent on the import of soy as the main source of proteins. With the more widespread cultivation of GM varieties that are approved in the exporting countries but not, or not yet, in the EU, potential trade disruptions could become more severe, more frequent, and affect more products. Impurities or contaminations in commodities are difficult to avoid, and it is common practice in food-safety legislation that minute presence is allowed of certain unwanted materials. According to law products in the EU may contain up to 0.5% of unapproved GM material that has received positive risk assessment from the European Food Safety Authorities. Conventional unlabeled products may contain up to 0.9% of approved GM material and 0% of GM material that has not undergone a safety review. If the presence of unapproved GM soy in imported soy exceeds this threshold, the product has to be destroyed, which involves enormous costs. Relaxing the zero-tolerance policy for unapproved GM-soy varieties to an alternative tolerance threshold might prevent the import decline and consequential problems. The aim of this research is to assess the quantitative impact on the EU import of GM soy of the EU policy on GM soy. The study evaluates 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. 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 is applied for the Netherlands. The time horizon is four years.

In the event of an introduction of a new GM variety in the US in production year t, a one-year delay in EU approval for new varieties results in a sufficient supply of EU-tolerant soy to meet the EU soy demand level of 33m. ton in 2008 for any threshold level from 0.0% to 100.0%. For all later production years, a delay in EU approval for new varieties of already one year results in insufficient supply of EU-tolerant soy to meet the EU soy demand level of 33m. ton in 2008

for any threshold up to the level of 0.9%. Sensitivity analysis indicates that if the growth of EU-unapproved GM varieties in all three countries is only 5% sufficient EU-tolerant soy is available to meet the 2008 EU soy demand level of 33 million ton for a tolerance threshold of 0.5% or higher in the first year after approval in the three countries. If production of a new variety of GM soy in Brazil closely follows EU approval for this variety, for all tolerance thresholds for unapproved GM soy total supply of EU-tolerant soy exceeds EU soy demand of 33 million ton. A delay in EU approval for new varieties for only one year does only affect estimated GM soy prices marginally, with an increase in mean values of prices from €290.0 to €292.2 per ton. However, a delay for two or more years increases estimated soy prices to over €7,747 per ton or higher for all thresholds up to 0.9%. When the production of a new GM variety in Brazil follows EU-approval for this variety, the GM soy prices remains unaffected with the current tolerance threshold levels, and demand remains at the same level. A two-year delay period will have a significant impact on feed prices. The tolerance of GM unapproved soy should be adjusted to over 0.9% to maintain the current soy price levels. The tolerance thresholds below 0.9% result in soy prices of €7,747 per ton or higher. If soy price increases from €290 to €7,747, farm level production costs increase with factor 8 for cattle, 10 for sows, 14 for finishing pigs and factor 18 for layer hens and broilers. At these price levels there will be no EU demand for soy as a raw material for feed, and the EU livestock industry will face a severe loss of competitiveness.

In conclusion, this study clearly demonstrates that the length of the EU approval process for new GM varieties has a higher impact on availability and price of EU-approved GM soy and non-GM soy than tolerance thresholds up to 0.9%. The maximum delay in the EU approval policy for new GM soy varieties is one year. A two-year delay period leads to insufficient supply of soy, and a consequential loss of competitiveness for the EU livestock industry. If Brazil and the EU have the same approval policy, supply problems are not expected.

Samenvatting

Invloed van de tolerantiedrempel en niet-gelijktijdige goedkeuring voor genetisch gemodificeerde soja in de diervoederindustrie in de EU

De teelt van genetisch gemodificeerde (gg) soja heeft vanaf 1996 een snelle groei doorgemaakt, met name in Noord- en Zuid-Amerika. De afgelopen jaren zijn er in toenemende mate problemen geweest met de invoer van soja in de EU vanuit belangrijke exporterende landen. Dit wordt onder meer veroorzaakt door de langdurige procedure in de EU voor de goedkeuring van nieuwe genetisch gemodificeerde organismen (ggo's) in combinatie met een nultolerantie voor sporen van niet-toegestane rassen. De veeteelt in de EU is echter sterk afhankelijk van de invoer van soja als de belangrijkste bron van eiwitten. De meer wijdverbreide teelt van gg-rassen die wel in de exporterende landen zijn toegestaan maar (nog) niet in de EU, kan leiden tot ernstigere en frequentere potentiële handelsverstoringen die van invloed zijn op meer producten.

Onzuiverheden of besmettingen in basisproducten zijn lastig te vermijden en het is gebruikelijk in de voedselveiligheidswetgeving dat de aanwezigheid van minieme hoeveelheden van bepaalde ongewenste stoffen is toegestaan. Bij wet mogen producten in de EU maximaal 0,5% niet-toegestaan gg-materiaal bevatten dat een positieve risicobeoordeling heeft gekregen van de Europese Autoriteiten voor Voedselveiligheid (EFSA). Conventionele producten zonder etiket mogen maximaal 0,9% niet-toegestaan gg-materiaal bevatten en 0% gg-materiaal dat geen risicobeoordeling heeft ondergaan. Als geïmporteerde soja meer niet-toegestane gg-soja bevat dan is toegestaan volgens deze drempel, moet het product worden vernietigd. Dit brengt enorme kosten met zich mee. Door het nultolerantiebeleid voor niet-toegestane gg-sojarassen te versoepelen zodat er een alternatieve tolerantiedrempel ontstaat, kunnen een daling van de invoer en eventuele problemen die daaruit voortvloeien worden voorkomen.

Het doel van deze studie is het evalueren van alternatieve tolerantiedrempels voor niet-toegestane gg-soja in de EU in combinatie met alternatieve vertragingsperiodes voor EU-goedkeuring voor het gebruik van dergelijke soja in diervoeder ten opzichte van goedkeuring voor productie in soja-exporterende landen. Voor de scenarioanalyse is gebruik gemaakt van een stochastisch computermodel van een keten met drie segmenten van sojaproducenten in de VS,

Brazilië en Argentinië, EU-importeurs en mengvoederproducenten. Het model is toegepast op de Nederlandse situatie. De tijdshorizon is vier jaar.

Als de toename van niet-toegestane gg-rassen in alle drie de landen slechts 5% is, dan is er voldoende door de EU goedgekeurde soja om aan de vraag naar soja in de EU in 2008 van 33 miljoen ton te voldoen voor een tolerantie-drempel van 0,5% of hoger in het eerste jaar na goedkeuring in de drie landen. Als de goedkeuring door de EU voor nieuwe rassen een vertraging oploopt van 2 jaar of meer, is er onvoldoende door de EU goedgekeurde soja beschikbaar om aan de vraag naar soja in de EU te voldoen voor alle drempelniveaus tot 0,9%. Als Brazilië meteen met de productie van een nieuw ras gg-soja begint nadat dit ras is goedgekeurd door de EU, is het totale aanbod van door de EU goedgekeurde soja groter dan de vraag naar soja in de EU van 33 miljoen ton voor alle tolerantiedrempels voor niet-toegestane gg-soja. Een vertraging in de goedkeuring van de EU voor nieuwe rassen van slechts één jaar heeft slechts een marginale invloed op de geschatte prijzen van gg-soja. De gemiddelde prijs stijgt dan van € 290,0 naar € 292,2 per ton. Bij een vertraging van 2 jaar of meer neemt de geschatte sojaprijs echter toe tot ruim € 7.747 per ton of meer voor alle drempels tot 0,9%. Wanneer de productie van een nieuw gg-ras in Brazilië van start gaat nadat de EU dit ras heeft goedgekeurd, heeft dit met de huidige tolerantiedrempels geen invloed op de prijzen van gg-soja en blijft de vraag gelijk. Een vertragingsperiode van twee jaar heeft een aanzienlijke invloed op de voerprijzen. De tolerantie van niet-toegestane gg-soja moet worden aangepast naar meer dan 0,9% om de huidige sojaprijzen te behouden. Een tolerantie-drempel van minder dan 0,9% leidt tot sojaprijzen van € 7.747 per ton of hoger. Als de sojaprijs toeneemt van € 290 naar € 7.747, nemen de productie-kosten op bedrijfsniveau toe met een factor 8 voor vee, met een factor 10 voor zeugen, met een factor 14 voor vleesvarkens en met een factor 18 voor leg-hennen en kuikens. Bij dit prijsniveau zal er in de EU geen vraag zijn naar soja als grondstof voor diervoeder, waardoor de veeteelt in de EU te maken krijgt met een aanzienlijk zwakkere concurrentiepositie.

Uit de analyse op basis van dit model blijkt duidelijk dat de duur van het EU-goedkeuringsproces voor nieuwe gg-rassen een grotere invloed heeft op de be-schikbaarheid en de prijs van door de EU goedgekeurde gg-soja en niet-gg-soja dan tolerantiedrempels tussen de 0,0 en de 0,9%. Tot slot is de maximale ver-traging in het EU-goedkeuringsbeleid voor nieuwe gg-sojarassen één jaar ten opzichte van de productie van dit gg-sojaras in de VS. Een vertragingsperiode van twee jaar leidt tot onvoldoende aanbod van soja en als gevolg daarvan een slechtere concurrentiepositie van de veeteelt in de EU. De tolerantiedrempel van

0,0 tot 0,9% heeft geen invloed op deze conclusie. Als Brazilië en de EU hetzelfde goedkeuringsbeleid hanteren, worden er geen problemen met het aanbod verwacht.

1   Background

1.1   Introduction

Over the last years the EU had increasing difficulties with the import of GM food and feedstuffs. This was caused by the zero-tolerance policy for unapproved GM varieties in the EU. The EU zero-tolerance policy for unapproved GM varieties means that only batches without any traces of EU-unapproved GM varieties can be imported. Because of a lengthy approval procedure in the EU, new GM varieties can already been grown and marketed during the procedure. This has already led to difficulties to import raw materials from countries where these new GM varieties had already been approved and produced. With the more widespread cultivation of GM varieties that are approved in the exporting countries but not, or not yet, in the EU, potential trade disruptions could become more severe, more frequent, and affect more products. Imports may be interrupted, slowed down considerably or come to a halt altogether, as traders may become unwilling to assume the risk of having traces of EU non-approved GM varieties detected in their shipments. A number of these incidents have already taken place in the past, for example the LL 601 rice incident in 2006 and Roundup Ready 2 Yield soy in 2008. All this contributes to higher feed prices and food prices, and to a loss of competitiveness for the EU livestock industry, as the Commission recently articulated (European Commission, 2007). It is likely that in the near future these problems will become more urgent, due to the emergence of new global consumer markets in Asia (Backus et al., 2008). Major suppliers to the EU are less and less obliged to strict EU requirements, whilst there are bigger and faster growing markets to supply.

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. Around 75% of soy used in the feed industry is imported, mostly from the USA, Argentina and Brazil. The coming years it is expected that new GM soy varieties will be produced in these countries. If the EU approval for use of these varieties in feed is delayed compared to approval for the production in these countries, this would reduce the amount of soy available for the EU feed industry. Cross contamination and mixing of EU-unapproved GM varieties with non-GM and EU-approved GM varieties combined with the zero-tolerance policy, can lead to difficulties for the EU to import sufficient soy. The problem is espe-

cially severe for soy, as it cannot be sufficiently produced in the EU. An interruption of soy availability may significantly decline EU livestock production, leading to substantial disruptions to livestock producers, related suppliers and processors. Without a sufficient supply of feed ingredients which forces livestock operators to use less satisfactory and more costly alternatives, the competitiveness of EU livestock production will weaken further and European livestock operators will loose market share in domestic and world markets to foreign competitors.

Impurities or contaminations in traded commodities are difficult to avoid, and it is common practice in food safety legislation that minute presence is allowed of certain unwanted materials. Comparable to the presence threshold of 0.9% of GM in non-GM batches, relaxing the zero-tolerance policy might prevent the import decline and consequential problems. The aim of this research is to assess the quantitative impact of the EU policy regarding GM soy on possible trade problems with the EU import of GM soy. This study evaluates alternative tolerance thresholds for EU-unapproved GM soy in combination with alternative delay periods of EU approval for GM unapproved soy for use in feed, compared to approval for production in soy exporting countries. Different scenarios were analysed. Scenario analyses were carried out 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 is applied for the Netherlands.

1.2 GM soy

The commercial production of GM soy crops started in 1996. In 2007 total GM soy production area accounted for more than 114 million hectares worldwide. Production is concentrated in the USA, Brazil and Argentina accounting for about 80 per cent of the total soy production area in 2007.

The first generation of GM soy increases expected yields and/or reduces the cost of weed and pest control and the quantity of insecticides used to control insect populations. The revealed preference of farmers' adoption choices, despite the price premium on seed of GM soy varieties, points towards such efficiency gains. These efficiency gains have lead to a substantial increase of GM production (table 1.1). Only in Brazil a substantial part of the total production area (34% in 2007, or 8 million hectares) is still used to produce non-GM soy.

Table 1.1		Adoption percentage of GM soy production in exporting countries									
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
USA	13	35	50	55	71	77	81	85	87	89	91
Brazil	2	8	15	24	30	32	34	34	49	56	66
Argentina	23	61	90	94	97	99	99	99	99	99	95
Source: www.soystats.com.											

Currently three GM soy varieties are approved in the EU (Table 1.2) and four varieties are pending approval (Table 1.3). Approved varieties are Roundup Ready (RR), Liberty Link (LL), and Roundup Ready 2 yield (RR2). The first commercial variety of GM soy introduced in 1996 in the USA was RR of the Monsanto Company. This is the only GM variety in soy currently released in Argentina and Brazil. Production of LL is expected to start in 2009 in the USA, whereas introduction in Argentina and Brazil is still under the consideration. Brazil is expected to decide on the approval of commercial production of LL soy in 2009 (Bindraban et al., 2008).

The second generation RR2 is a substitute for RR and provides up to 7% higher yield compared to RR. RR2 is expected to be launched widely in the USA by 2009. The four second generation GM soybean varieties pending approval in the EU are 356043 (Optimum GAT), 305423 (TREUS), 305423 x 40-3-2 and A5547-127. These varieties do not substitute existing varieties, but are expected to be produced next to the already existing varieties.

Table 1.2	GM soybean traits approved in the EU			
Event	Applicant	Trait	Date of approval
MON40-3-2 (Roundup Ready)	Monsanto	Herbicide tolerant	03/04/1996
MON89788 (Roundup Ready 2 yield)	Monsanto	Herbicide tolerant	04/12/2008
A2704-12 (Liberty Link)	Bayer Crop-Science	Herbicide tolerant	08/09/2008
Source: EFSA, http://www.efsa.europa.eu.				

Table 1.3	GM soybean traits pending approval in the EU		
Event	**Applicant**	**Trait**	**Date of request for approval**
356043 (Optimum GAT)	Pioneer Hi-Breed	Herbicide tolerant	11/04/2007
305423 (TREUS)	Pioneer Hi-Breed	Herbicide tolerant High oleic acid content	18/06/2007
305423 x 40-3-2	Pioneer Hi-Breed	Herbicide tolerant High oleic acid content	24/09/2007
A5547-127	Bayer CropScience	Herbicide tolerant	03/04/2008
356043 (Optimum GAT)	Pioneer Hi-Breed	Herbicide tolerant	11/04/2007
Source: EFSA, http://www.efsa.europa.eu.			

1.3   Report structure

The paper is structured as follows: Chapter 2 presents material and methods, where model structure and input data used in the model are described. Main empirical results are discussed in chapter 3, and conclusions and discussion in chapter 4.

2 Material and methods

2.1 Model structure

The analysis assumes a three-tiered supply chain of soy producers in the USA, Brazil and Argentina, EU importers and feed producers. The time horizon is four years. We use expected values for the years 2009, 2010, 2011 and 2012 as input for these four years. The results are presented with the years t, t+1, t+2 and t+3, because we aim to show the impact of a delay of EU approval for use in feed compared to the year of approval for the production in the exporting countries. Whether the production in the exporting countries is approved first in 2009, 2010 or 2011 is of less interest for this aim. A distinction is made be-tween non-GM soy, EU-approved GM soy, and EU-unapproved GM soy. Based on expert interviews the following model structure has been developed (figure 2.1).

2.1.1 Soy supply chain

The model describes the soy supply chain in general terms from the primary production in exporting countries up to and including the compound feed pro-ducers in the EU. From thousands of primary soy producers in the exporting countries the soy beans are transported by trucks to inland storages. From there the soy beans are transported by means of trucks, ship or trains to crushers or to storages in exporting harbours. After crushing the soy meal is stored in storages in exporting harbours. Then, the soy beans or meal is trans-ported to the EU in ships. The product arrives in EU harbours such as those of Amsterdam or Rotterdam, where it is unloaded, stored and finally transported by trucks, ships or trains to compound feed production locations. In the Nether-lands soy beans and meal are directly transported to the compound feed indus-try, whereas in other EU countries storage in the harbour prior to transportation to the compound feed industry is more common.

2.1.2 Risk of contamination

One of the major concerns regarding the importing of GM soy is the risk of the presence of EU-unapproved GM soy in a batch of non-GM soy or of EU-approved GM soy. In this study such presence is called contamination. Sources of con-

tamination are: 1) out crossing of EU-unapproved GM soy into neighbouring fields with non-GM soy or EU-approved GM soy, 2) mixing of EU-approved GM soy and EU-unapproved GM soy during transport and storage, 3) cross contamination of a batch of non-GM or of EU-approved GM soy with traces of EU-unapproved GM varieties during transportation and storage. According to experts the risk of contamination is high during transportation and storage in the exporting countries and low at the primary producers and at the importers. We therefore assume that contamination of batches of non-GM and EU-approved GM soy with EU-unapproved GM soy happens prior to shipment to the EU.
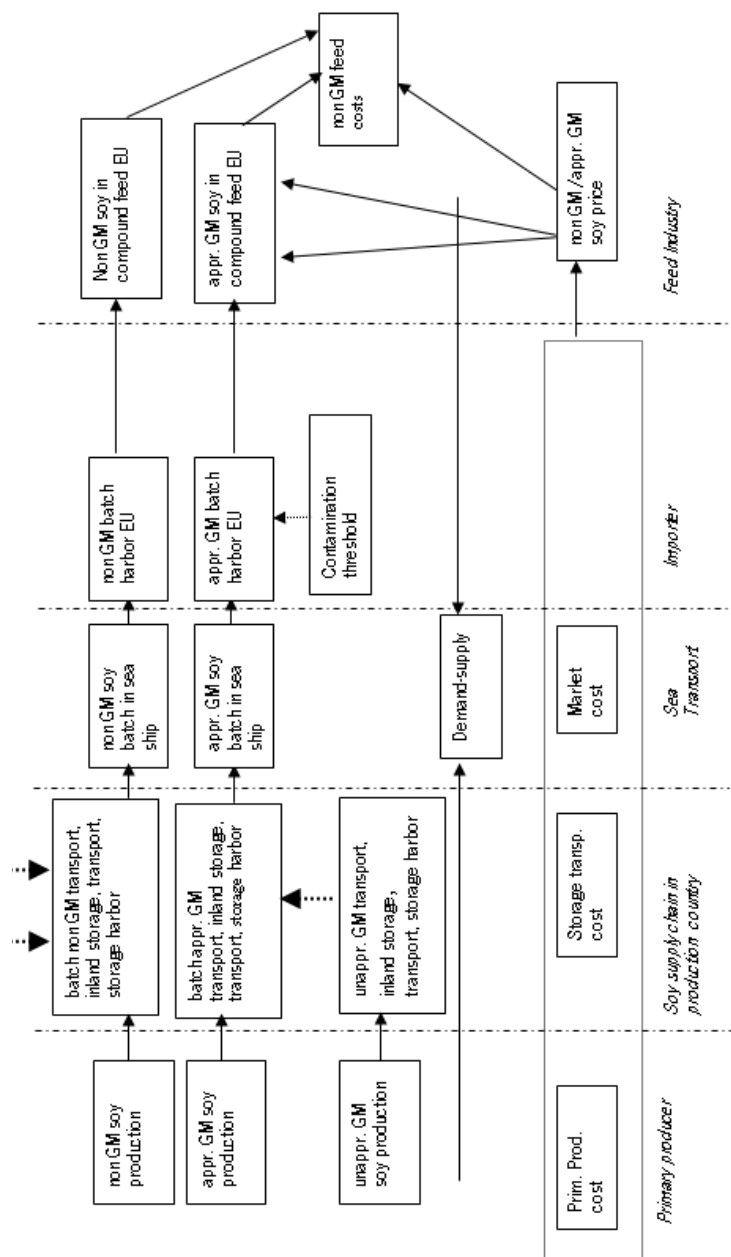
To identify contamination in a batch of approved GM soy or non-GM soy tests are conducted. A batch of soy is generally tested twice. The first test is conducted during loading of the ship by the importer prior to shipment to EU. Test results are available about a week after the test. This means that the ship has already been heading towards the EU for a week. Possible contaminated batches can still be redirected towards Northern Africa without too high costs. The second test is conducted after it arrives into the EU during unloading of the ship. If contamination is found, the batch has to be recalled and the recalled part can be redirected to other markets or it has to be destroyed. In the Netherlands the second test is carried out by the Dutch Food and Consumer Product Safety Authority (VWA). We assume that the test carried out by VWA is perfect, so the test correctly identifies if a sampled batch is GM-unapproved positive or not.

2.1.3 Modules of the model

The model has three modules and several in-between steps. The first module calculates total available soy for the EU, which includes GM-approved and non-GM soy. In the remainder of this report GM-approved and non-GM soy together are referred to as *EU-tolerant soy*. Expert estimation of the probability of contamination with EU-unapproved GM soy determines the available amount of EU-tolerant soy for each tolerance threshold. The second module is a partial equilibrium model that uses EU demand and the available EU-tolerant soy to calculate market costs. Market costs are the price premium if soy availability is restricted. The primary production, processing, transport, and market costs are added to calculate the expected price of EU-tolerant soy. Relating soy price to feed composition determines EU demand for EU-tolerant soy. The third module calculates feed prices for various threshold levels. Scenario analyses with different tolerance thresholds and share percentages of EU-unapproved GM soy

Figure 2.1 **Model structure**

provide insight into the impact of alternative tolerance thresholds for
EU-unapproved GM soy on soy supply, soy prices and feed prices.

2.2   Input data

This section explains the estimation of input data and scenario descriptions for
module one (total available EU-tolerant soy for the EU) followed by the estima-
tion of input data for module two (partial equilibrium mode) and module three
(calculations of feed prices).

2.2.1   Available EU-tolerant soy

The calculation of the first module involves several steps. The first step starts
with the calculation of total GM and non-GM soy production for the years
t,…,t+3 in the USA, Brazil and Argentina. The minimum, most likely, and maxi-
mum values of adoption percentage of GM soy production in these three coun-
tries (Table 2.1) were elicited, based on historical data from Table 1.1 and ex-
perts judgments.

Table 2.1	Expected adoption of GM soy in exporting countries based on expert judgement (% of total production)			
	t	t+1	t+2	t+3
USA				
Min	91	91	91	91
Most Likely	95	95	95	95
Max	99	99	99	99
Brazil				
Min	66	66	66	66
Most Likely	85	85	85	85
Max	99	99	99	99
Argentina				
Min	95	95	95	95
Most Likely	97	97	97	97
Max	99	99	99	99

Data from Table 2.1 were used in the second step to calculate the total GM
and non-GM soy production in three exporting countries using a triangular distri-

bution function. The triangular distribution can, if no sample data are available, be fully specified from the minimum, most likely, and maximum values provided by experts (Hardaker et al., 2004). Table 2.2 provides the most likely values of total soy production in the three exporting countries.

Table 2.2	Most likely total soy production in three exporting countries (1,000 ton)			
	t	t+1	t+2	t+3
USA				
Estimated non-GM	4,194	4,091	4,243	4,211
Estimated GM	79,694	77,731	80,615	80,016
Estimated total production	83,889	81,822	84,858	84,228
Brazil				
Estimated non-GM	11,605	12,174	12,639	13,081
Estimated GM	58,024	60,872	63,196	65,404
Estimated total production	69,628	73,046	75,835	78,485
Argentina				
Estimated non-GM	1,536	1,572	1,600	1,628
Estimated GM	50,832	52,012	52,945	53,871
Estimated total production	52,369	53,584	54,545	55,499
USA, Brazil, Argentina				
Estimated non-GM	17,335	17,837	18,482	18,920
Estimated GM	188,550	190,615	196,756	199,291
Estimated total production	205,886	208,452	215,238	218,211
Source: www.fapri.org for total soy production data.				

The third step in module one was to calculate the number of EU-tolerant soy batches contaminated with EU-unapproved GM soy based on different scenarios and share % of EU-unapproved GM soy in total soy production. Each batch was assumed to consist of 6,000 ton.

2.2.2 Tolerance thresholds

Scenario analyses were carried out to provide insight on the impact of alternative tolerance thresholds for EU-unapproved GM soy on soy supply to EU. The

scenarios are based on alternative tolerance thresholds of EU-unapproved GM soy and different shares of EU-unapproved GM soy in the USA, Brazil and Argentina. The analysed tolerance threshold values are 0.0%, 0.1%, 0.2%, 0.5%, 0.9% and 100.0% (no threshold) of EU-unapproved GM soy in a batch of EU-tolerant soy. Expert judgment was used to elicit the probability of contamination of EU-tolerant soy batches with EU-unapproved GM soy for each tolerance threshold value for each country (Table 2.3).

The 0% in the first column with contamination level 0.0% means that if the share of EU-unapproved GM soy in the USA/Argentina is 5% of total GM production, the probability is 0% that the contamination level in a batch of EU-tolerant soy is 0.0%. The 10% in the same column for Brazil with the contamination level of 0.2%-0.5% means that if the share of EU-unapproved GM soy in the Brazil is 5% of total GM production, the probability is 10% that a batch of EU-tolerant soy contains between 0.2%-0.5% EU-unapproved GM soy.

The decision problem is analysed by developing a stochastic simulation model using @Risk, with different input values under different scenarios. To obtain insight into the distribution of the impact of the contamination levels of EU-tolerant soy with EU-unapproved GM soy, a Monte Carlo simulation model was applied. In a Monte Carlo simulation, selected variables or relationships incorporate random or stochastic components by specifying probability distributions, to reflect important parts of uncertainty in the real system (Hardaker et al., 2004). Since contamination probabilities have stochastic nature, this method is considered to be an appropriate method for this analysis. The expected number of contaminated batches cont_batch is calculated as:

$$cont\_batch = n * p$$

where n is the number of possible available EU-tolerant batches (Table 2.2) and p the contamination probability (Table 2.3). The total expected amount of available EU-tolerant GM soy tol_soy is then calculated as

$$tol\_soy = (n - cont\_batch) * batch\_size$$

where batch_size is 6,000 tonnes.

Table 2.3	Assumed probability percentages of EU-tolerant soy batches being contaminated with EU-unapproved GM soy depending on share levels of EU-unapproved GM soy in total soy production			
Contamination level	Share of EU-unapproved GM soy in total soy production (% of total GM soy production)			
	5	25	50	75
USA, Argentina				
0.0%	0	0	0	0
>0.0-0.1%	0	0	0	0
>0.1-0.2%	1	0	0	0
>0.2-0.5%	9	0	0	0
>0.5-0.9%	10	0	0	0
>0.9%	80	100	100	100
Brazil				
0.0%	5	0	0	0
>0.0-0.1%	5	0	0	0
>0.1-0.2%	20	5	0	0
>0.2-0.5%	10	5	0	0
>0.5-0.9%	20	10	0	0
>0.9%	40	80	100	100

The following step in this module is the calculation of the impact of delays in EU approval for new GM varieties not yet approved in the EU on the supply levels of EU-tolerant soy to EU from the three countries. This is based on growth percentage of GM soy that has not yet been approved in the EU, different tolerance thresholds of EU-unapproved GM soy, and contamination levels.

2.2.3 Asynchronic approval

Because historical data were not available, expert judgment was used to determine the minimum, most likely and maximum values of the growth percentages of new GM soy varieties (Table 2.4). Production of a new GM variety starts in the USA and only in the following year production can be expected in Brazil and Argentina. The production of a new variety in Brazil and Argentina progresses less rapidly than in the USA.

Table 2.4	Assumed production of new GM soy varieties (% of total production in the country)			
Production year	**t**	**t+1**	**t+2**	**t+3**
USA				
Min	5	10	15	20
Most Likely	10	15	20	25
Max	15	20	25	30
Brazil, Argentina				
Min	0	5	10	15
Most Likely	0	10	15	20
Max	0	15	20	25

To evaluate the expected impact of a delay of EU approval of new GM soy varieties for use in feed compared to the approval for the production in the USA, Brazil and Argentina, four scenarios were developed (Table 2.5). For all scenarios the production of a new variety of GM soy starts in year t in the USA. In scenario 1 we assume that the production of the new variety in Brazil and Argentina takes place in year t+1 and that the EU approves a new GM variety in year t+1. This scenario thus provides the impact of a one-year delay of approval of a new variety on the supply volumes to EU and on the prices of EU-approved GM soy. In scenario 2 we assume that again the production of the new variety in the USA starts in year t and in Brazil, Argentina in year t+1, but EU approval of a new GM variety is in year t+2. This scenario thus provides the impact of a 2 years delay of approval of a new variety. The other two scenarios are designed similarly for three and four years delay of approval in the EU.

Taking into account the fact that in Brazil the GM soy production grows less rapidly than in the USA and Argentina, four additional scenarios were developed, in which the approval for production of new GM soy varieties in Brazil follows the approval of these varieties in the EU (Table A1.1 in Appendix 1).

There is a high level of uncertainty around the duration of the approval process in the EU. Therefore sensitivity analyses are carried out for scenario 4 using different share percentages of unapproved varieties of 5, 25, 50 and 75% in total soy production for the years t, t+1, t+2, t+3 in all three countries.

Table 2.5	'Delay in EU approval of new varieties' scenarios				
		t	t+1	t+2	t+3
Scenario 1: EU approval in t+1					
Approved for production in					
USA		X	X	X	X
Brazil			X	X	X
Argentina			X	X	X
Approved in EU			X	X	X
Scenario 2: EU approval in t+2					
Approved for production in					
USA		X	X	X	X
Brazil			X	X	X
Argentina			X	X	X
Approved in EU			-	X	X
Scenario 3: EU approval in t+3					
Approved for production in					
USA		X	X	X	X
Brazil			X	X	X
Argentina			X	X	X
Approved in EU			-	-	X
Scenario 4: EU approval in t+4					
Approved for production in					
USA		X	X	X	X
Brazil			X	X	X
Argentina			X	X	X
Approved in EU			-	-	-

2.2.4 Partial Equilibrium Model

The second module of the model involves a Partial Equilibrium Model. This model is used to calculate the increase in soy price if the available amount of EU-tolerant soy decreases. The relationship between worldwide soy production, soy demand from the EU, and the world soy price was based on data on non-GM soy (Table 2.6), because insufficient data were available on EU-approved GM soy varieties.

Table 2.6	World non-GM soy production (m. ton), EU non-GM demand (m. ton), excess supply above EU demand (m. ton), total EU demand for non-GM and GM soy (m. ton), and additional non-GM soy price (€/ton) for 1999-2008									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
World non-GM soy production a)	67.5	65.3	54.1	53.0	46.7	48.0	40.1	35.7	29.2	26.8
EU non-GM demand b)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Excess supply above EU demand	58.5	56.3	45.1	44.0	37.7	39.0	31.1	26.8	20.2	17.8
Total EU Soy Demand c)	29	31	35	34	33	33	34	34	36	33
Price premium d)	0.00	0.00	0.00	2.65	4.43	4.02	8.05	7.97	43.86	54.65

Source: a) Own calculations based on Table 1; b) Based on 27% non-GM soy in 2004 (Brookes, 2004);
c) EU Import of soy meal and soy meal equivalents (Eurostat) d) Cardy Brown (2008).

The price premium was estimated with the excess supply above the EU demand, because outside the EU no specific demand for EU-approved GM soy varieties is to be expected. The relationship between price premium and excess supply is presented as a simple constant elasticity form:
price premium = $\alpha \cdot$ (excess supply)$^{\varepsilon}$ (Breukers et al., 2008). Using the data from Table 2.7 the following relationship was derived ($R^2 = 0.971$):

Price premium = $1{,}559{,}798 \cdot$ (Excess supply)$^{-3.544}$ (1)

Excess supply was calculated as the difference between the global supply of EU approved varieties and the demand from the EU:

Excess supply = world production - EU demand   (2)

The demand from the EU depends on the price of soy and was calculated based on data provided by the feed industry (Table 2.7).

Table 2.7	Soy price and % of soy in animal feed in the Netherlands				
Soy price (€/ton)	**290 a)**	**340**	**390**	**490**	**690**
Soy in feed in the Netherlands b)	11.0	10.55	10.3	9.85	9.15
Estimated soy use in feed in EU c)	24.3	23.9	23.6	23.2	22.5

a) Base price of soy meal determined as the average price of 1997-2006. In 2008 RR2 was produced in the USA increasing soy prices; b) Source: results from a commercial feed optimization; c) The average soy percentage in EU in 2007 of 24.3% (Van Gelder et al., 2008) was used as the percentage at the base price. The percentages at the other prices are lowered with the difference as observed in the Netherlands.

The relationship between EU demand and soy price was estimated with a simple constant elasticity form: EU demand = $\alpha \cdot$ (soy price)$^{\varepsilon}$. Using the data from Table 2.8 the following relationship was derived ($R^2 = 0.997$):

$$\text{EU-demand} = 59.374 \cdot (\text{soy price})^{-0.089} \qquad (3)$$

Where the soy price is the sum of the primary production costs, processing costs, transport costs, and the price premium. In equilibrium the EU demand as determined by the soy price equals the world production of soy minus the excess demand above the EU demand, which determines the soy price. The partial equilibrium model of the equations (1), (2) and (3) was numerically solved.

2.2.5 Feed price

The last module of the model calculated the impact of various threshold levels and share % of unapproved GM soy on prices of feed for layer hens, broilers, sows, finishing pigs and cattle. This module relates soy prices to feed composition for each animal type. The base feed prices in 2008/2009 (Table 2.8) were used when calculating the impact of assumed soy price increases on the feed price. A commercial optimisation model with the current available raw materials was used to calculate the effects of a soy price increase from €50 to €400 per ton. All feed quality and environmental restrictions to the feed as valid for current feeds with the base soy price were met in the optimization for all soy prices.

Table 2.8	**Feed prices per animal category depending on soy price 2008/2009**				
	Price and additional price a) (%) above base price at soy price (€/ton)				
Soy price	**290**	**340**	**390**	**490**	**690**
Feed price layer hens	198 b)	+6.5	+13.5	+39.0	+60.0
Feed price broilers	236 b)	+5.0	+13.0	+28.5	+51.0
Feed price sows	180 b)	+6.5	+12.5	+26.5	+48.0
Feed price finishing pigs	190 b)	+5.0	+10.0	+20.0	+35.0
Feed price cattle	185 b)	+4.0	+10.0	+20.0	+40.0
Source: a) results from a commercial feed optimisation; b) KWIN Veehouderij 2008/2009.					

3 Empirical results

3.1 Available EU-tolerant soy

Subsection 3.1.1 presents the model results on the available amount of EU-tolerant soy, when the production of a new EU-unapproved GM soy variety starts in year t in USA and in year t+1 in Argentina and Brazil. Subsection 3.1.2 presents the results when the production of EU-unapproved GM varieties in Brazil follows EU approval for these varieties.

3.1.1 EU approval independent of approval in exporting countries

The combined results for scenarios 1 to 4 are presented in Table 3.1 taking into account the production in three countries combined (USA, Brazil and Argentina). The results per country are presented in Appendix 2 (Tables A2.1-A2.3). The values presented in the table are mean values. Results for the 5% and 95% percentile are presented in Appendix 2 (Tables A2.4-A2.6). In the event of an introduction of a new GM variety in the US in production year t, a one-year delay in EU approval for new varieties results in a sufficient supply of EU-tolerant soy to meet the EU soy demand level of 33 million ton in 2008 for any threshold level from 0.0% to 100.0%. For all later production years, a delay in EU approval for new varieties of already 1 year results in insufficient supply of EU-tolerant soy to meet the EU soy demand level of 33 million ton in 2008 for any threshold up to the level of 0.9%. However, EU soy demand does also depend on soy prices. The impact of price on EU soy demand is presented in paragraph 3.2.
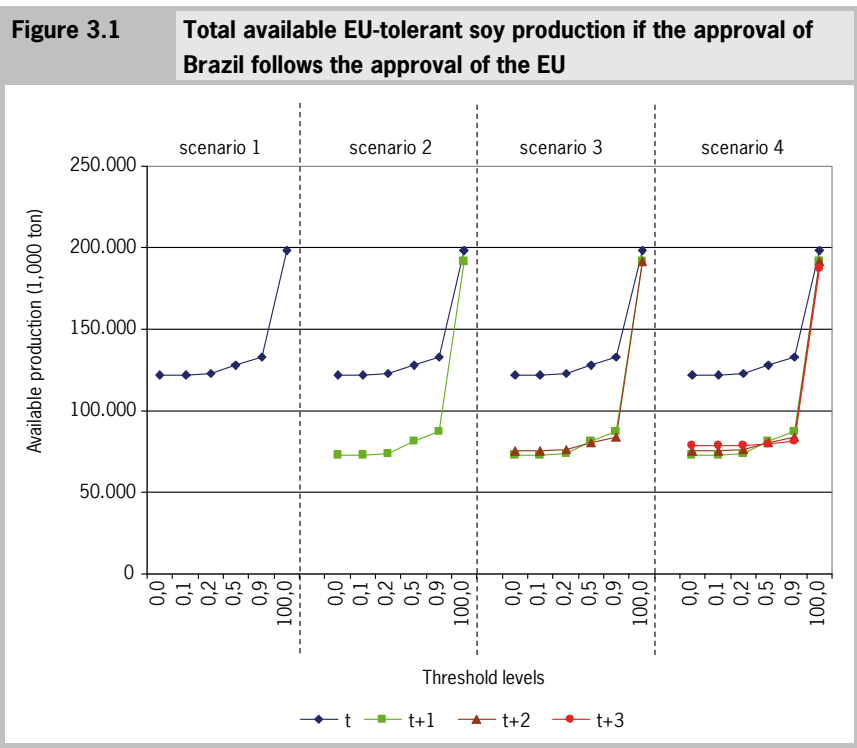
Table 3.2 presents the combined results over the three countries of the sensitivity analyses for scenario 4 with the shares of unapproved varieties of 5, 25, 50 and 75% in total soy production for the years t, t+1, t+2, t+3 respectively. The results per individual country are presented in Appendix 3 (Table 3.1). If the share of EU-unapproved GM varieties in all three countries is only 5%, sufficient EU-tolerant soy is available to meet the 2008 EU soy demand level of 33 million ton for a tolerance threshold of 0.5% or higher in the first year after approval in the three countries. In the following years for all threshold levels up to 0.9% insufficient EU-tolerant soy is available to meet the EU soy demand level for 2008.

Table 3.1	Scenarios 1-4. Impact of delay in EU approval of a new variety on production availability of EU-tolerant soy from the USA, Brazil, and Argentina depending on threshold level for years t-t+3			
	Production year			
Approval year	**t**	**t+1**	**t+2**	**t+3**
t+1	↓a)	a.a. b)	a.a. b)	a.a. b)
t+2	↓	↓	a.a. b)	a.a. b)
t+3	↓	↓	↓	a.a. b)
t+4	↓	↓	↓	↓
Threshold (%)	**Mean values of total available production of EU-tolerant soy (1,000 ton)**			
0.0	121,997	0	-	-
0.1	121,997	4,535	3,201	1,263
0.2	123,201	7,939	6,019	2,879
0.5	127,636	24,351	16,354	6,838
0.9	132,910	31,275	21,114	9,007
100.0	197,915	185,508	181,692	165,126

a) ↓: see second half of the table for the total available production of EU-tolerant soy depending on the threshold;
b) All available: the GM variety is also approved in the EU, so no availability restrictions exist.

Table 3.2	Sensitivity analyses for scenario 4 for total available production of EU-tolerant soy from the USA, Brazil, and Argentina by threshold level			
	t	**t+1**	**t+2**	**t+3**
Share of unapproved GM in total soy production	**5%**	**25%**	**50%**	**75%**
Threshold (%)	**Mean values of total available production of EU-tolerant soy (1,000 ton)**			
0.0	0	0	0	0
0.1	7,038	0	0	0
0.2	20,496	2,946	0	0
0.5	40,218	7,080	0	0
0.9	67,380	12,486	0	0
100.0	196,452	160,800	116,862	68,742

3.1.2 Production approval in Brazil follows EU approval

The results of the scenarios in which the approval for production of new GM soy
varieties in Brazil follows the approval of these varieties in the EU are presented
in Figure 3.1. If production of a new variety of GM soy in Brazil closely follows
EU approval for this variety, for all tolerance thresholds for unapproved GM soy
total supply of EU-tolerant soy exceeds EU soy demand of 33 million ton in
2008.

Figure 3.1	Total available EU-tolerant soy production if the approval of Brazil follows the approval of the EU

3.2   Results with the Partial Equilibrium Model

Subsection 3.2.1 presents the results for the price of EU-tolerant soy and the
EU soy demand for the case when the production of a new EU-unapproved GM
soy variety starts in year t in USA and in year t+1 in Argentina and Brazil. Sub-

section 3.2.2 presents the results when the production of EU-unapproved GM
varieties in Brazil follows EU approval for these varieties.

3.2.1 EU approval independent of approval in exporting countries

A delay in EU approval for new varieties for only 1 year only affects estimated GM
soy prices marginally, with an increase in mean values of prices from €290.0 to
€292.2 per ton. However, a delay for 2 or more years increases estimated soy
prices to over €7.747 per ton or higher for all thresholds up to 0.9%.
Figure 3.2 presents the results for estimated EU-demand for GM soy if EU-
demand is an endogenous variable based on the estimated soy price. The EU
demand for soy remains constant in year t, when soy prices are constant, and it
decreases considerably in years t+1-t+3, due to increased in soy prices.

Figure 3.2	EU demand for soy if EU-demand is an endogenous variable based on the soy price
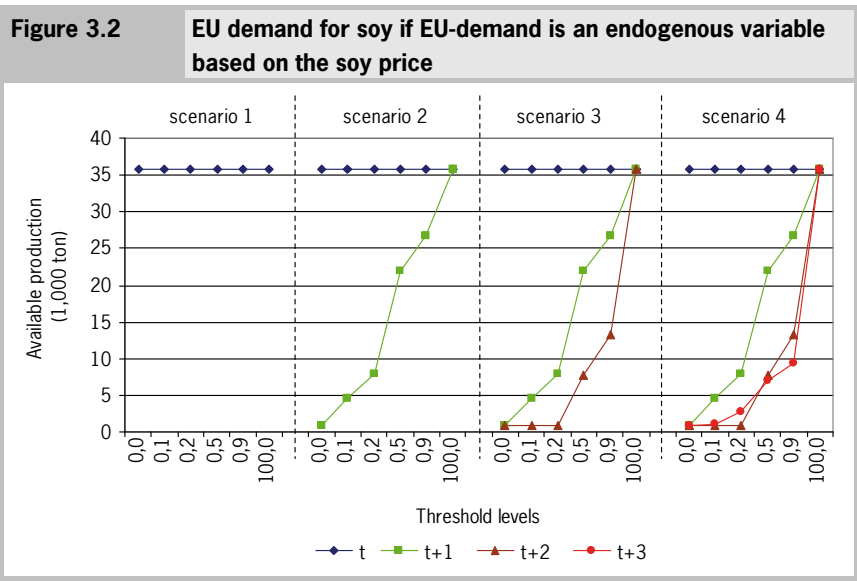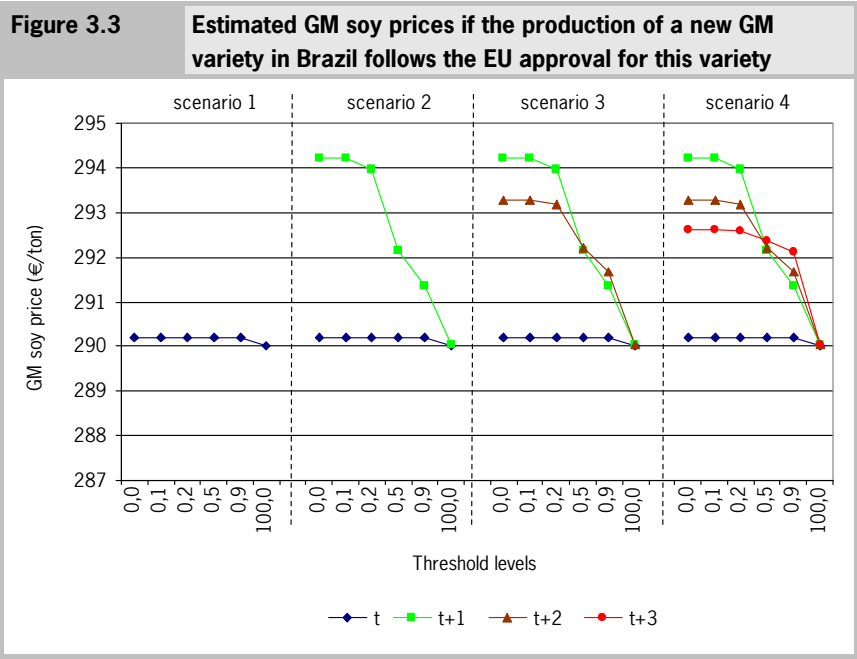
Table 3.3	Sensitivity analyses for estimated soy prices (€/ton) for scenario 4			
Year	**t**	**t+1**	**t+2**	**t+3**
Share of unapproved GM soy	5%	25%	50%	75%
Threshold (%)				
0.0	>50,000	>50,000	>50,000	>50,000
0.1	>50,000	>50,000	>50,000	>50,000
0.2	>50,000	>50,000	>50,000	>50,000
0.5	1,112	>50,000	>50,000	>50,000
0.9	297	>50,000	>50,000	>50,000
100.0	290	290	290	290

Table 3.4	Sensitivity analyses for estimated EU demand for soy (million ton) for scenario 4			
Year	**t**	**t+1**	**t+2**	**t+3**
Share of unapproved GM soy	5%	25%	50%	75%
Threshold (%)	**EU demand (m. ton)**			
0.0	0.91	0.91	0.91	0.91
0.1	6.98	0.91	0.91	0.91
0.2	18.99	2.94	091	0.91
0.5	31.80	7.02	0.91	0.91
0.9	35.76	12.12	0.91	0.91
100.0	35.85	35.85	35.84	35.78

Sensitivity analysis results for an increased share of unapproved GM soy in total soy production for scenario 4 (described in section 2.2.3) are presented in Tables 3.3 and 3.4. An increase in the share of unapproved GM varieties up to 5% of total soy production in all exporting countries, and a delay in EU approval for new GM varieties for several years (t+4), already requires adjustments in the tolerance threshold levels to at least <0.5% in order to be able to maintain reasonable soy prices and the EU demand level for soy.

3.2.2 Production approval in Brazil follows EU approval

Figure 3.3 presents the results of estimated GM soy prices when the production of a new GM variety in Brazil follows the approval of EU this variety. In line with the results from Figure 3.1, if production of a new variety of GM soy in Brazil follows EU approval for this variety, the GM soy prices remains unaffected with the current tolerance threshold levels.

Figure 3.3	Estimated GM soy prices if the production of a new GM variety in Brazil follows the EU approval for this variety

In line with the estimated prices in Figure 3.3, calculations of EU demand for soy when the production of a new GM variety in Brazil follows the approval of EU this variety reveal a constant demand of 35 million ton for all scenarios in years t -t+4.

3.3 Results Feed Price Effect

Based on the results of the impact of a delay in EU approval of a new variety on estimated GM soy prices, a delay of 1 year will not impact on feed prices, since

soy prices remain the same. A delay of 2 years or more will have a significant impact on feed prices. The tolerance of GM unapproved soy should be adjusted to over 0.9% to maintain a soy price at €290 and current feed price. The tolerance thresholds below 0.9% result in very high soy prices (€7,747 per ton or higher). Table 3.5 shows that if soy price increases from €290 to €7,747, the model calculates an increase in production costs by a factor of 8 for cattle and a factor of 18 for layer hens and broilers. At these price levels there will be no EU demand for soy as a raw material for feed, and the EU livestock industry will face a severe loss of competitiveness within the short term.

Table 3.5	Effect of increase of soy price on livestock production costs				
	Feed costs at soy price of €290/ton a)	Feed costs at soy price of €7,747/ton	Feed cost as % of total farm production costs	Production costs at €290/ton	Production costs at soy price of €7,747/ton
Animal type	€/ton	€/ton	%	€/animal b)	factor increase
Layer hens	198	1290	65 a)	1247	18
Broilers	236	1166	66 a)	750	18
Sows	180	803	36 a)	152	10
Finishing pigs	190	601	51 a)	92	14
Cattle	185	663	28 a)	962	8
a) Source: KWIN Veehouderij 2008-2009, b) production costs for hens and broilers are given per100 animal.					

4   Conclusions and discussion

The aim of this research is to assess the quantitative impact of the EU policy regarding GM soy on possible trade problems with the EU import of GM soy. This study evaluates alternative tolerance thresholds for EU-unapproved GM soy in combination with alternative delay periods of EU approval for GM unapproved soy for use in feed, compared to approval for production in soy exporting countries. Different scenarios were analysed. Scenario analyses were carried out 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. Our results show how the EU approval process affects the import of soy into the EU. In fact the duration of the EU approval process for new GM varieties has more impact on availability and price of EU-tolerant soy than adjustments of tolerance thresholds. Importing soy into the EU is going to become more difficult. The maximum delay in the EU approval process for new GM soy varieties compared to the introduction of this GM-soy variety in the USA is one year. A two-year delay period leads to soy supply problems, and to a loss of competitiveness for the EU livestock industry. This conclusion is not influenced by the chosen tolerance threshold level for acceptance as not containing unapproved GM soy varieties within the range 0.0-0.9%. When both Brazil and the EU have the same approval policy, supply problems are not expected.

Based on the results of this study it can be suggested that the policy makers should rather focus on adjustments of the duration of the approval policy for new GM soy varieties than adjustment of tolerance thresholds, because the EU livestock industry is highly dependent on the import of soy and delay in approval procedure may cause serious trade disruptions. Even if the share of EU-unapproved GM varieties in all three countries will be only 5%, a tolerance threshold needs to be adjusted to 0.5% or higher in the first year in order to meet 2008 EU soy demand level of 33 million ton. However in the following years for all threshold levels up to 0.9% insufficient EU-tolerant soy is available to meet the EU soy demand level, unless the EU approval procedure will be synchronised.

Overlooking this issue may lead to very high feed costs, which will force feed producers and livestock industry to search alternative solutions, such as e.g. substitution of soy with other protein rich materials (e.g. peas or grains). However, technical feasibility and the social-economic impact of such alternative

solutions need further research. An alternative solution to this problem could be the strengthening of institutional arrangements in the exporting countries, in order to prevent the contamination risks of GM approved soy with GM unapproved soy. This could be done by enforcing stricter control and monitoring of the exported product to the EU at the exporting harbour as well as during transportation. However, such arrangements still entail higher costs, due to monitoring and control costs, which will eventually affect feed prices and furthermore, the EU still risks a shortage of EU tolerant soy supply.

It must be emphasised that the specific findings presented here depend on the underlying behavioural and technical assumptions and on the particular set of scenarios considered. Sensitivity analysis suggests, however, that the superiority of the short delay period - one year or less - is robust, and is not influenced by the chosen tolerance threshold level within the range from 0.0 to 0.9%.

The need to simplify the analysis has resulted in at least three limitations. First, in determining soy supply to the EU data were lacking on the probabilities of EU-tolerant soy batches being contaminated with EU-unapproved GM soy depending on the growth levels of EU-unapproved GM soy. Expert judgment was used to elicit the probability of contamination of EU-tolerant soy batches with EU-unapproved GM soy for each tolerance threshold value for each country.

Second, historical data for the growth percentage of new GM soy varieties and the price premium of approved GM soy varieties are lacking. A probability distribution with assumed minimum, most likely and maximum values of the growth percentages of new GM soy varieties reflects this uncertainty. The price premium for non-GM soy over the last years was used to estimate the price premium of approved-GM soy varieties. The world demand for non-GM soy mainly originated from the EU, as is the world demand for EU-approved GM soy varieties. It is therefore assumed that the price premium of non-GM soy represents the price premium of EU-approved soy.

Third, a partial equilibrium model was used with only endogenous EU demand and exogenous supply from three major exporting countries. Expanding this analysis to include endogenous world supply, where the decision to produce a GM soy variety depends on the world price, could yield useful insights on price quantity relationships for soy and feed.

The model does not allow for distinguishing between EU-approved GM soy and non-GM soy. Although non-GM soy is important for the EU food industry and organic feed industry, it is only a small fraction of total soy use. The analysis assumed that the probabilities of contaminations of non-GM soy and EU approved GM soy with EU-unapproved GM soy were equivalent. The contamination

probabilities with EU-unapproved varieties in the non-GM soy supply chain are expected to be lower than in the supply chain of EU-approved GM soy. Therefore, most non-GM soy produced in the exporting countries will probably be available. The identity preservation of non-GM soy will include logistical and certification costs, even if demand for non-GM soy remains at the current level. Thus, one might expect a higher price premium for non-GM soy than for EU-approved GM soy. The non-GM soy price premium depends also on the adoption rate of GM soy. The adoption percentage of GM soy production in Brazil did increase steadily during the last few years. If this development continues, supply of non-GM soy will become more and more difficult, resulting in even higher price premiums. Alternatively, this development may stay at the current level or even decrease in case the price premium for non-GM soy will be at such a level that GM soy will lose its main attraction of lower production cost. Such a price premium for non-GM soy implies a decrease in GM soy production in favour of non-GM soy production with no risk for exporting countries to lose the EU market or for the EU feed industry to lose their sourcing. Future research could highlight the price difference between non-GM and EU-approved GM soy.

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Appendix 1

Scenario 'Brazil follows EU'

Table A1.1 describes that the production of EU-unapproved varieties in Brazil follows the timing of EU-approval of these varieties. This means that that production percentage of a new variety in Brazil in a year equals zero, if this variety is not approved in EU in that year. Consequently, no contamination is possible in that year, meaning the whole production amount from Brazil is available for the EU.

Table A1.1	Scenarios EU approval of new varieties, when production of new varieties in Brazil follows Approval in the EU			
	t	t+1	t+2	t+3
Scenario 1 EU approved t+1				
Approved for production in				
USA	X	X	X	X
Brazil	-	X	X	X
Argentina	-	X	X	X
Approved in EU	-	X	X	X
Scenario2 EU approved t+2				
Approved for production in				
USA	X	X	X	X
Brazil	-	-	X	X
Argentina	-	X	X	X
Approved in EU	-	-	X	X
Scenario 3 EU approved t+3				
Approved for production in				
USA	X	X	X	X
Brazil	-	-	-	X
Argentina	-	X	X	X
Approved in EU	-	-	-	X
Scenario 3 EU approved t+4				
Approved for production in				
USA	X	X	X	X
Brazil	-	-	-	-
Argentina	-	X	X	X
Approved in EU	-	-	-	-

Appendix 2

Scenario results per individual country

Tables A2.1-A2.3 provide the results per exporting country.

Table A2.1	Scenarios 1-4. The impact of a delay in EU approval of a new variety on production availability for years t-t+3 from the USA				
Approved in EU (year)		**Threshold (%)**	**Total production available for EU from US with contamination levels (mean values) (1,000 ton)**			
t+1			**t**	**t+1**	**t+2**	**t+3**
		0.0	0			
		0.1	0			
		0.2	550			
		0.5	4,636			
		0.9	10,058			
		100.0	75,918			
t+2						
		0.0	0	0		
		0.1	0	0		
		0.2	550	280		
		0.5	4,636	4,557		
		0.9	10,058	6,921		
		100.0	75,918	70,164		
t+3						
		0.0	0	0	0	
		0.1	0	0	0	
		0.2	550	280	121	
		0.5	4,636	4,557	1,183	
		0.9	10,058	6,921	2,446	
		100.0	75,918	70,164	68,736	
t+4						
		0.0	0	0	0	0
		0.1	0	0	0	0
		0.2	550	280	121	0
		0.5	4,636	4,557	1,183	212
		0.9	10,058	6,921	2,446	371
		100.0	75,918	70,164	68,736	64,224

Table A2.2		Scenarios 1-4. The impact of a delay in EU approval of a new variety on production availability for years t-t+3 from Brazil			
Approved in EU (year)	**Threshold (%)**	**Total production available for EU from Brazil with contamination levels (mean values) (1,000 ton)**			
t+1		**t**	**t+1**	**t+2**	**t+3**
	0.0	69,628	0		
	0.1	69,628	4,535		
	0.2	69,628	7,312		
	0.5	69,628	16,394		
	0.9	69,628	17,277		
	100.0	69,628	66,960		
t+2					
	0.0	69,628	0		
	0.1	69,628	4,535		
	0.2	69,628	7,312		
	0.5	69,628	16,394		
	0.9	69,628	17,277		
	100.0	69,628	66,960		
t+3					
	0.0	69,628	0	0	
	0.1	69,628	4,535	3,201	
	0.2	69,628	7,312	5,738	
	0.5	69,628	16,394	11,699	
	0.9	69,628	17,277	12,931	
	100.0	69,628	66,960	66,354	
t+4					
	0.0	69,628	0	0	0
	0.1	69,628	4,535	3,201	1,263
	0.2	69,628	7,312	5,738	2,773
	0.5	69,628	16,394	11,699	5,725
	0.9	69,628	17,277	12,931	6,457
	100.0	69,628	66,960	66,354	56,178

Table A2.3	Scenarios 1-4. The impact of a delay in EU approval of a new variety on production availability for years t-t+3 from Argentina				
Approved in EU (year)		Threshold (%)	Total production available for EU from Argentina with contamination levels (mean values) (1,000 ton)		
t+1			t	t+1	t+2	t+3
		0.0	52,369	0		
		0.1	52,369	0		
		0.2	52,369	347		
		0.5	52,369	3,400		
		0.9	52,369	7,077		
		100.0	52,369	48,384		
t+2						
		0.0	52,369	0		
		0.1	52,369	0		
		0.2	52,369	347		
		0.5	52,369	3,400		
		0.9	52,369	7,077		
		100.0	52,369	48,384		
t+3						
		0.0	52,369	0	0	
		0.1	52,369	0	0	
		0.2	52,369	347	161	
		0.5	52,369	3,400	3,471	
		0.9	52,369	7,077	5,737	
		100.0	52,369	48,384	46,602	
t+4						
		0.0	52,369	0	0	0
		0.1	52,369	0	0	0
		0.2	52,369	347	161	106
		0.5	52,369	3,400	3,471	901
		0.9	52,369	7,077	5,737	2,180
		100.0	52,369	48,384	46,602	44,724

Tables A2.4-A2.6 provide the results of the 'best' (95% percentile) and the 'worst' (5% percentile) cases. The 5% percentile is the value in the data set, below which 5% of the observations may be found, while in case of 95% percentile is the value below which 95% observations may be found.

Table A2.4		Scenarios 1-4. The impact of a delay in EU approval of a new variety on production availability for years t-t+3 from US (best and worst cases)							
Approved in EU (year)	Thresh-old (%)	Total production available for EU from US with contamination levels (95% and 5% percentiles) (1,000 ton)							
			t		t+1		t+2		t+3	
			95%	5%	95%	5%	95%	5%	95%	5%
t+1										
		0.0	0	0						
		0.1	0	0						
		0.2	143	44						
		0.5	1,021	779						
		0.9	1,887	1,492						
		100.0	12,653	12,653						
t+2										
		0.0	0	0	0	0				
		0.1	0	0	0	0				
		0.2	143	44	199	65				
		0.5	1,021	779	849	546				
		0.9	1,887	1,492	1,591	1,177				
		100.0	12,653	12,653	11,694	11,694				
t+3										
		0.0	0	0	0	0	0	0		
		0.1	0	0	0	0	0	0		
		0.2	143	44	199	65	199	65		
		0.5	1,021	779	849	546	849	546		
		0.9	1,887	1,492	1,591	1,177	1,591	1,177		
		100.0	12,653	12,653	11,694	11,694	11,694	11,694		
t+4										
		0.0	0	0	0	0	0	0	0	0
		0.1	0	0	0	0	0	0	0	0
		0.2	143	44	199	65	199	65	13	0
		0.5	1,021	779	849	546	849	546	66	0
		0.9	1,887	1,492	1,591	1,177	1,591	1,177	103	0
		100.0	12,653	12,653	11,694	11,694	11,694	11,694	10,704	10,704

Table A2.5		Scenarios 1-4. The impact of a delay in EU approval of a new variety on production availability for years t+1-t+3 a) from Brazil (best and worst cases)						
Approved in EU (year)		**Threshold (%)**	**Total production available for EU from Brazil with contamination levels (95% and 5% percentiles) (1,000 ton)**					
			t+1		**t+2**		**t+3**	
			95%	**5%**	**95%**	**5%**	**95%**	**5%**
t+2								
		0.0	0	0				
		0.1	945	332				
		0.2	1,471	964				
		0.5	3,097	2,314				
		0.9	3,262	2,296				
		100.0	11,160	11,160				
t+3								
		0.0	0	0	0	0		
		0.1	945	332	615	181		
		0.2	1,471	964	911	175		
		0.5	3,097	2,314	1,945	1,393		
		0.9	3,262	2,296	2,065	1,550		
		100.0	11,160	11,160	11,059	11,059		
t+4								
		0.0	0	0	0	0	0	0
		0.1	945	332	615	181	289	75
		0.2	1,471	964	911	175	465	155
		0.5	3,097	2,314	1,945	1,393	1,028	454
		0.9	3,262	2,296	2,065	1,550	1,181	446
		100.0	11,160	11,160	11,059	11,059	9,363	9,363

a) The year t is not taken in the table, because it is assumed that Brazil will not have a new variety production in a year t, thus the contamination will not be present.

Table A2.6			Scenarios 1-4. The impact of a delay in EU approval of a new variety on production availability for years t+1-t+3 a) from Argentina (best and worst cases)					
Approved in EU (year)	Threshold (%)		Total production available for the EU from Brazil with contamination levels (95% and 5% percentiles) (1,000 ton)					
			t+1		t+2		t+3	
			95%	5%	95%	5%	95%	5%
t+2								
		0.0	0	0				
		0.1	0	0				
		0.2	95	0				
		0.5	691	390				
		0.9	1,572	796				
		100.0	8,064	8,064				
t+3								
		0.0	0	0	0	0		
		0.1	0	0	0	0		
		0.2	95	0	33	0		
		0.5	691	390	376	258		
		0.9	1,572	796	817	566		
		100.0	8,064	8,064	7,767	7,767		
t+4								
		0.0	0	0	0	0	0	0
		0.1	0	0	0	0	0	0
		0.2	95	0	33	0	22	0
		0.5	691	390	376	258	253	84
		0.9	1,572	796	817	566	373	165
		100.0	8,064	8,064	7,767	7,767	7,454	7,454

a) The year t is not taken in the table, because it is assumed that Argentina will not have a new variety production in a year t, thus the contamination will not be present.

Appendix 3

Sensitivity analyses per individual country

Table A3.1 provides the results of the sensitivity analysis per exporting country.

Table A3.1	Sensitivity analyses for scenario 4			
		t	t+1	t+2	t+3
Share % unapproved		5%	25%	50%	75%
Threshold (%)	Total production available for the EU from the USA with contamination levels (mean values) (1,000 ton)			
USA					
0.0		0	0	0	0
0.1		0	0	0	0
0.2		1,104	0	0	0
0.5		7,860	0	0	0
0.9		17,454	0	0	0
100.0		79,902	62,388	44,550	24,216
Brazil					
0.0		0	0	0	0
0.1		7,038	0	0	0
0.2		19,194	2,946	0	0
0.5		28,170	7,080	0	0
0.9		41,424	12,486	0	0
100.0		66,726	57,828	44,238	29,430
Argentina					
0.0		0	0	0	0
0.1		0	0	0	0
0.2		198	0	0	0
0.5		4,188	0	0	0
0.9		8,502	0	0	0
100.0		49,824	40,584	28,074	15,096

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