Costs and Benefits for the Co-existence of GM and non-GM Maize

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"GM and non-GM supply chains: Their CO-EXistence and TRAceability"

CO-EXTRA

Costs and Benefits for the Co-existence of GM and non-GM Maize

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1 Introduction

So far, studies analysing the economic impact of GM crops focus on the farm level and do only partly consider the entire supply chain from primary producer, to processors, distributors and retailers. Some authors provide a rather global analysis of costs and benefits (Moschini et al., 2005, Bullock et al., 2002).

Little work is done on the economy of co-existence on company level. This aspect is relevant due to the fact, that today, the segmentation of markets for GM-, non-GM and organic crops is common for food production and causes costs. This segmentation of markets is, on the one hand, a result of the concept of co-existence in the EU. This concept demands, that farmers have the right to grow a GM crop, if they wish, and consumers have the right to buy the produce that comes from it. At the same time, farmers also hold the right to cultivate non-GM crops, and provide EU consumers with non GM harvest.

On the other hand, the EU directive on the traceability of genetically modified food (Regulation (EC) 1830/2003) demands, that the direct use of GMOs at any point in their production are subjected to labelling requirements, regardless of whether or not GM content is detectable in the end product. Therefore, a specialised traceability infrastructure must be developed by the companies to fulfil the new process-oriented regulatory system.

Each operator or trader of GM raw materials, ingredients, or foods is obligated to pass information on to subsequent stakeholders in the food supply chain. Documentation must be retained for five years. It must always be possible to trace the route of a GMO from the farm to the final product. Upon authorisation, every GMO is assigned an ID number that can be used to identify it at all times. Local governments are responsible for monitoring and the GMO content of products and supervise the companies

The European Commission made an initial contribution to co-existence policy in the form of guidelines to help Member States develop national approaches (2003/556/EC[1]). The Commission Recommendation states that co-existence measures should not go beyond what is necessary to ensure that accidental traces of GMOs in non-GM products stay below EU labelling thresholds of 0.9% in order to avoid any unnecessary burden for the operators concerned. In addition, measures should be science-based, proportionate, must not generally forbid the growing of GM crops and protect producers of non-GM crops from the possible economic consequences of accidental mixing of non-GM crops with GMOs. But adventitious presence of GM material in conventional or organic crops may arise at any stage in the supply chain and from a variety of sources such as seed impurities, cross pollination, germination of volunteers, transport and seed left in planting, harvesting and storage equipment or human error. Also for suppliers, this causes additional measures like additional testing, documentation, negotiation with contractors and suppliers, and liability costs in the case of system failure. These measures necessitate changes in production practices and hence involve additional costs.

The aim of the report is therefore to provide information on costs and benefits with respect to the co-existence genetically modified (GM) and non GM maize supply chains in selected European countries.

To this end, this study describes first of all typical maize supply chains in Europe and identifies the critical points for co-existence along the entire supply chain: seed production, farm level,

[1] Commission Recommendation of 23. July 2003 on guidelines fort he development of national strategies and best practices to ensure the co-existence of genetically modified crops with conventional and organic farming (notified under document number C(2003)2624)

elevator level and processing. In a second step, the co-existence costs will be estimated along the entire supply chains on the basis of three case studies covering grain maize (Switzerland), starch maize (Germany) and maize for silage (Denmark).

2 Costs of co-existence in maize supply chains: literature overview

Originally a tropical plant, today maize (*Zea mays*) is cultivated worldwide and even in temperate zones on acreage of 157 million ha in 2007. The United States of America are responsible for 40 % of worldwide production. Other important production countries are China, Brazil, Mexico, Argentina, India, Indonesia, South Africa as well as Italy and France in the EU (TransGen Wissenschaftskommunikation, 2009a).

Maize is – together with rice and wheat – the most important cereal in the world. In many southern countries, especially Central- and South-America, maize plays a decisive role in nutrition of the population. Thus, a multiplicity of traditional maize products exist (e.g. tortillas, tacos) in these countries. More than two third of the world wide maize production is used as livestock feed (gluten and maize for silage). In 2008 in the EU, GM maize was cropped in Spain (79,269 ha), Czech Republic (8,380 ha), Portugal (4,851 ha), Germany (3,171 ha), Poland (3,000 ha) and in Slovakia (1,900 ha) (TransGen Wissenschaftskommunikation, 2009a). The situation of GM-field trials worldwide in 2008, applications, approvals and growing situation worldwide is shown in the overview table 1.

The EU has an equated export-import-balance for maize products. Maize, maize gluten (for forage purposes), maize food products or single ingredients are imported from USA and Argentina. The probability of GM occurrence might increase if the growing of GM maize varieties in EU countries will be increased in future (TransGen Wissenschaftskommunikation, 2009a).

2.1 Economic performance of Bt-maize

The potential economic benefits of the first generation of GM crops (Herbicide tolerance, Insect resistance or a combination of these two modifications) may arise as on-farm benefits such as higher yields (Gomez-Barbero et al., 2008) and reduced operating and labour costs for pesticide treatments or weed control (Marlander, 2005). Benbrook (2001) and Eder (2007) however report that for Bt maize not in any case higher yields could be expected. This is due to i) that Bt trait is not yet implemented in high-yield varieties, ii) the high yield potential of conventional varieties which might compensate losses under low to medium European corn borer infestation and iii) that yield difference become particularly relevant in situations with high corn borer infestation (Wolf and Albisser Vögeli, 2009). Therefore, Bt-maize yields might increase particularly in regions with a high infestation level to the European corn borer (table 2).

Furthermore, due to the resistance of Bt-maize against the European corn borer, insecticide use is often reported to decrease when cultivating Bt-maize. The resulting savings could be quite relevant, however, it needs to be stressed that in only about 6-20% of the total Spanish maize crop area (Brookes, 2002) and about 33% of the German maize crop area (Brookes, 2006) uses insecticide treatments to control corn borer attacks.

Table 1: GM maize field trials worldwide: approvals and growing in 2008

Number of field trials with GM maize:			
EU:	Totally 845 field trial applications, France 280, Spain 263, Italy 98, Belgium 28, Hungary 26, Germany 30; others: the Netherlands, Portugal, Romania, UK, Greece, Denmark, Poland, Czech Republic, Austria, Sweden, Slovakia, Lithuania Period: 1992-2009 traits: herbicide tolerance, insect resistance (Bt), modified contents of ingredients, molecular pharming, changed flowering time, drought tolerance		
USA:	About 6,600 field trials, Period: 1986-2008		
Other countries:	Argentina, Canada, New Zealand, Japan, Columbia, China, South Africa, India		
Number of approvals for GM maize varieties:			
EU:		*Crop growing*	*Forage/food*
	petitions	10	19
	approvals	2	12
	Traits: herbicide tolerance, insect resistance, modified contents of ingredients		
Other countries:		*Crop growing*	*Forage/food*
	USA	24	26
	Argentina	10	9
	Australia		16
	China		9
	Japan	26	33
	Canada	23	25
	Korea		24
	Mexico		23
	Philippines	4	30
	Traits: insect resistance, viral resistance, Amylase, higher Lysin content		
Commercial growing of GM maize			
EU	In 2008: Spain 79,269 ha, Czech Republic 8,380 ha, Portugal 4,851 ha, Germany 3,171 ha, Poland 3,000 ha, Slovakia 1,900 ha.		
USA	Growing of GM maize since 1997: 28 million ha in 2008 (80% of total maize area)		
Other countries	Argentina 2.8 mio ha, South Africa 1.6 mio ha, Canada 1.17 mio ha, Philippines 250,000 ha, Honduras 7,000 ha		

Source: TransGen Wissenschaftskommunikation (2009a)

Table 2: Change of economic parameters of conventional maize compared to Bt-maize

Economic Parameter	Trait	Reported changes of parameter in GM maize	Source	Country
Gross margin	IR	↑	Marra et al. (1998)	USA
	IR	↑ (if infestation is high)	Rice and Pilcher (1998)	USA
	IR	↓	Fernandez-Cornejo and McBride (2002)	USA
	HT	↑	Fernandez-Cornejo and McBride (2002)	USA
	IR	↓ (1998-1999)	Carpenter and Gianessi (2001)	USA
	IR	↑ (1997)	Carpenter and Gianessi (2001)	USA
	IR	↑ (if area with high infestation levels)	Hyde et al. (1999)	?
	IR	↔ (if area with low to medium infestation levels)	Hyde et al. (1999)	?
	IR	13%↑	Gomez-Barbero et al. (2008)	Spain
Yield	IR	1.8 % - 2.5 % ↑	Brookes (2002)	Spain
	IR	5 % ↑	Brookes (2002)	Spain
	IR	↑ (if infestation is high)	Rice and Pilcher (1998)	USA
	IR	↑	Carpenter and Gianessi (2001)	USA
	IR	↑	Hyde et al. (1999)	?
	HT	↓ (1996-2001) ↑ (2002-2003)	Benbrook (2003)	USA
	IR	-0.1 % - 11.6 % (average 4.7% ↑	Gomez-Barbero et al. (2008)	Spain
Herbicide	IR	0 % -100 % ↓	Brookes (2002)	Spain
Insecticide	IR+HT	↓ (1996-2001) ↑ (2002-2003)	Benbrook (2003)	USA
Herbicide + Insecticide	IR + HT	↓	Fernandez-Cornejo and McBride (2002)	USA
	IR	↔	Carpenter and Gianessi (2001)	USA
	IR	30 % -35 % ↑	Benbrook (2001)	USA, Canada
Costs of seeds	IR	12 % -19 %↑	Brookes (2002)	Spain
	IR	30 % -35 %↑	Benbrook (2003)	USA, Canada
IR: Insect resistance (mostly resistance due to *Bacillus thuringiensis* (Bt) toxin) HT: Herbicide tolerance				

Source: based on Menrad and Reitmeier (2006) updated in 2009

The gross margin differences between GM and non-GM crops are in most studies mainly influenced by the following factors:

- Assumed higher yields of Bt-maize due to better pest tolerance
- Additional premium price of non-GM maize due to higher co-existence costs and lower trader and consumer acceptance of GM products
- Additional seed costs due to extra technology fees of Bt- maize varieties. Gómez-Barbero and Rodruigez-Cerezo (2007) stated that Spanish companies developing GM seed usually recommend a “royalty fee” to distributors, although the final price paid by farmers also depends on their bargain power (presence and role of co-operatives, farm size, etc.)
- Savings in pest control (reduced number of applications of insecticides against corn borer by farmers growing Bt-maize)

An overview of some studies and the considered impacts on the gross margin is given in table 3. It is obvious that the range of the identified total benefit in the gross margins is significant. It reaches from over 120 €/ha in Saragossa down to even a negative effect in US regions (in a specific year). By considering the different assumed yields, price premiums and variable costs and savings it is quite clear that the gross margin differences strongly depend on the calculation approach and inserted basic information in a certain region.

Table 3: Overview over different studies presenting yearly average economic differences of Bt-maize compared to conventional maize in different regions

Source	Regarded region	**Economic (gross margin) benefit in €/ha**	Additional seed costs in €/ha	Savings in pest control in €/ha	Additional premium price of non-GM maize	Higher yield Bt-maize
Gómez-Barbero and Rodruigez-Cerezo, 2007	Albacete (Spain)	**7.28**	6.96	9.50	1.6%	< 0.5%
	Lleida (Spain)	**70.90**	28.79	4.50		> 2.0%
	Saragossa (Spain)	**124.90**	37.79	20.00		11.8%
Sausse, 2006	Alsace (France)	**40.10**	29.90	17.50	10%	4.7%
Gouse et al. 2005	Mpumalanga – irrigated land (South Africa)	**68.00**				
	Northern Cape – irrigated land (South Africa)	**119.00**				
Carpenter and Gianessi, 2001	USA, 1999	**-3.56**				

Sources: Gómez-Barbero and Rodruigez-Cerezo (2007); Sausse (2006)

So far, no scientific information is available on benefits of Bt maize for the food and the feed industry. Bullock et al. (2002) assumes cost reductions if food and feed processors could purchase GM raw materials at lower prices than conventional raw material. In future, new plants which might be more attractive to the needs of the industry (e.g. GM potato without amylo pectin) will appear on the market.

As far as potential additional costs of Bt maize production are concerned, the most relevant cost factor found in literature is the technology fee which farmers have to pay to the seed breeding company. Reitmeier et al. (2006) found for Germany additional costs of 34% for Bt maize seed. For Spain, Gómez and Rodriguez (2007) report additional Bt maize seed costs of 6.96€/ha to 37.79€/ha which corresponds to additional costs of 4 – 21%. Gomez and Rodrigo (2007) stress for Spain that the higher the infestation tension the higher the additional costs for Bt maize seeds. Furthermore, seed breeding companies seem to give a discount when introducing GM-corps (Schiefer et al., 2008)

Furthermore, at high Bt maize adoption rates, farms require to introduce resistance management strategies which consist of refuges cropped with non-Bt maize in order to avoid corn borer resistance. This resistance management will also cause additional costs for the Bt maize producer (opportunity costs).

In general, the economic performance of the GM technology varies between regions, crops, traits, pest and/or weed pressure and agronomic practice (Flannery et al. 2005, Marlander, 2005, Gomez-Barbero et al., 2008).

As we showed in table 1, from the case study countries Switzerland, Germany and Denmark, only in Germany Bt maize is cropped on a very limited area. Therefore, we need to use for our cost calculations also economic information from studies which were conducted in the USA and Spain where already experiences in cultivating Bt-maize have been made

2.2 Co-existence costs for non-GM maize supply chains

Non-GM maize supply

Due to the sceptical attitude of European consumers, raw materials containing genetically modified organisms (GMO) or GM material below the 0.9% threshold (established in the EU) or lower (QS Specifications) is traded. These raw materials originate from Hard Identity Preservation (IP) or Soft IP programmes respectively (Buckwell et al., 1998, Bullock et al., 2002, Kalaitzandonakes 2008).

With Hard IP, an acceptance contract is concluded between the farmer and the buyer prior to sowing. The harvest is placed at once in bags or sealed containers in order to separate it from the other goods. Organic production standards also require such a procedure.

Monitoring systems that are designated as „Soft IP“ do not inspect the flow of goods from farmer to buyer. The non-GM-derived crop has been certified as coming from non-GM growing regions but are often not subject to testing verification or are not accompanied by guarantees/certification as to the precise non-GM. ‘Soft IP’ systems have much lower costs than ‘hard IP’ systems in which there is strict IP of non-GM crop from point of production through the supply chain. The setting of strict tolerance levels for adventitious contamination with GM-derived material and regular testing through the supply chain ensure that supplies meet buyer specifications; Buckwell et al. (1998) estimates, that the additional costs for IP fall broadly in the range of 5% and 15% oft the farm gate price of the crop. Also Kalaitzandankes (2007) states, that IP implies additional production and logistic costs.

For the processors or retailers, there is the possibility to purchase certified non-GM products (Hard IP and Soft IP) via importers. Goods from such systems always have a higher price and are not traded on international grain exchanges. The cost determining factor is the degree of purity (% GM Material) demanded: the lower the GM material percentage allowed in the raw material, the higher the costs. In addition to the costs for the raw materials, there are costs for information exchange among the individual stakeholders (transaction costs).

Kalaitzandonakes (2003) investigated the cost of the global Identity Preservation Systems for agricultural goods. He pointed out, that the costs for IP have been consistently underestimated. He distinguish two groups of costs: direct costs coming form the coordination of farmers and sellers, changes on operations (cleaning, investments in new storages, testing) and risk (system failure) and indirect costs like underutilization of production, storage and transport assets, lost profits du to less flexibility on the grain markets.

In Germany, 2% of the food producers demand Hard IP goods from their suppliers, whereas a written declaration of the GM status (Soft IP) of the ordered goods suffices for 82% (Hirzinger and Menrad, 2005).

Raw material prices for maize

For maize, mainly non-GM commodities are produced within the EU. The demand for non-GM commodities from the EU can be met from these sources. For certified non-GM maize, the additional purchase costs in Austria are 3–10€/t (Moder et al., 2004). Brookes (2006) expects a medium-term 3–4% price increase for unmodified maize commodities, because inspections and additional production and storage measures will be necessary when more GM maize is grown in Europe.

In general, so far we cannot foresees how market prices for non-GM raw material will develop and what the economic impacts for the next supply chain levels might be. Moder et al. (2004) assumes that higher raw materials prices could make as much as 50% of the additional costs of subsequent supply chain levels.

Costs for supplier evaluation and selection

In order to ensure that their products are non-GM, processors and dealers must also take account of the upstream stages of the value chain. To do so, the suppliers must be known and non-GM status must be documented in written form.

Every raw material poses specific risks regarding GM-contamination. In order to be able to assess these risks, the production methods of the suppliers must be examined, and their quality management requires continuous monitoring and evaluation. For companies which import goods, these measures require extra work and result in additional expenses. In the study by Moder et al. (2004), the procurement of the raw materials for organic feedstuffs plants is listed as administration costs. The time required for this additional administrative work is estimated at ca. 60 h/a for a plant with a production volume of around 7,000 t/a and < 5% non-GM production.

Compliance declaration

With purchases of conventional ingredients, additives and processing aids, non-GM production by suppliers is confirmed by providing a GM compliance declaration upon demand by the buyers. The preparation and handling of the compliance declaration with the suppliers takes time and thus results in additional expense. An organic company in Germany (pers. communication) stated that it takes about two working days to handle compliance declarations with ca. 150 suppliers. This time is needed to instruct the suppliers regarding the compliance declaration and monitor receipt of completely filled out and signed declarations.

Transports

Raw materials from non-GM production processes can become contaminated during transport. In order to avoid contamination through contaminated vehicles and conveyors, in principle it is possible to prohibit previous loads of GMOs or GMO derivates. This measure will probably result in increasing costs and is therefore hardly feasible.

If a company insists on the previous three loads being free of GM/GM hazard materials, costs will increase. This is mainly due to the necessity of reorganizing transport logistics and cleaning, and also due to poorer capacity utilization of available means of transport. So far, no scientific literature on this issue is available.

Wenk et al. (2001) state with respect to additional transport costs "…if additional measures are taken (accompanying documentation, vehicle inspections, analyses, certificates, etc.), there may be additional costs. The price, however, is always subject to negotiation. Standard surcharges of 10% are considered realistic."

Certificates for previous loads are evidently easier to obtain for road freight than for rail transport.

In order to avoid contamination with a previous load containing GMOs, a suitable cleaning can be performed prior to transporting non-GM products. These costs are highly dependent on the nature and extent of the cleaning measures employed: either dry cleaning (vacuum suction) or wet cleaning may be necessary, depending on the previous load. The cleaning of means of transport is frequently carried out by specialized companies.

Receipt of goods
Receipt of goods represents the line between the individual company and its suppliers. In principle, at this interface it is necessary to check whether the raw materials fulfil the specified requirements. The co-existence measures to be taken are different in cases when a plant operates both GM and non-GM commodities in parallel compared to cases where only non-GM commodities are operated.

Upon receipt of goods, the following measures and costs arise to protect from undesired contamination a company that wants to produce non-GM products:

- Checking the documentation of delivered goods
- Sampling for laboratory analyses and reference samples
- Arrangement of additional storage

There is no literature available on the above-mentioned measures such as reference samples, inspection of the delivered goods. A reason for this might be, that the corresponding costs do not play a decisive role in economic appraisal, are difficult to assess, or are part of the quality assurance system already in place in the company anyway. However, it cannot be concluded in general that the above-mentioned measures do not result in any additional costs to companies. Tolstrup et al. (2003) assume for rapeseed processing that inspection and analysis of unprocessed goods result in a 4% additional cost. Some companies initially place each delivery received in quarantine storage for sampling and testing. Because laboratory tests usually take about a week, there must be storage capacity available for seven days. This measure is only practical for premium products (e.g. organic products).

Internal transport and storage
Internal transport, in which various materials are moved and various conveyor means are employed, takes place in most companies. In general, the risk of GM-contamination from internal transport is highly specific to the individual company. This risk is not an issue for companies that do not operate GM commodities; for all others, however, internal transport is an issue.

Partial or total cleaning of transport facilities
After processing GMOs, a unit can be wet or dry cleaned. The type and costs of the cleaning depend considerably on the unit and the product transported. An economic assessment can

therefore only be made on an individual case basis. There are no statements in the literature regarding the costs of cleaning internal transport and conveyor units.

For some conveyor units, there may be no additional cleaning costs because such facilities require routine cleaning anyway after each product change.

Flushing batches

In order to avoid GM-contamination in internal transport or production lines, facilities are cleaned with flushing batches. Flushing batches consist of conventional, non-GM products. In grain mills, such batches are barley or maize, which are sent through the production lines in order to remove, or at least dilute, residues of previously processed products as much as possible. Costs are incurred due to the loss of value of the product, and due to any time needed to readjust the facilities.

Storage

For companies that handle unmodified commodities only, there are no additional warehouse expenses, whereas companies processing both GM and unmodified commodities have to build new storage facilities for unprocessed goods and finished products. This results in investment costs, either for construction of new storage facilities and/or for cleaning.

Furthermore, it is necessary to instruct the warehouse employees on specific warehouse rules and designation regulations (Tolstrup et al., 2003).

Sampling

In order to avoid errors, processors, traders and producers must be aware of certain rules in sampling concerning the type, size and number of samples to be taken.

Employees therefore need to be trained in sampling techniques as well as how to spot potential sources of errors. This results in additional expenses. Further costs are incurred for documentation, packaging and the contracting of companies to perform the analyses. Sampling is often assigned to third parties. In some quality management programmes, the buyers already have a sampling plan in place that calls for a certain number of samples.

Laboratory analyses

The purpose of performing laboratory tests is to verify compliance with statutory and private-sector standards regarding the production process and to assure compliance with the requirements of individual suppliers. Analysis costs frequently account for the bulk of the extra cost. A survey of food producers in Germany showed that 57% of the actors of the milling industry mention higher costs for analytical GMO testing (Hirzinger and Menrad, 2005).

Summary

In table 3, we summarise information from literature on the potential additional costs for non-GM supply chains.

The magnitude of these costs is to some extent unknown and in addition heavily dependent on the complexity of the production process. Although the studies considered in the present review state the costs of the various items (table 4), it is almost impossible to make comparisons.

Table 4: Overview on potential additional costs for non-GM maize supply chains

	Add. Costs		
	Administration, Additional Personnel	Analyses	Additional commodity costs, transport, cleaning, storage
Wenk et al. (2001)			10%
Tolstrup et al (2003)	5% - 14%	4%	5% - 6%
Moder et al (2004)	5%	5%	40%

Moreover, it is also not possible to conclude on the total costs for a company or the price for the final products, as the latter also depends on other factors such as production volume, capacity utilization, supply and demand (AGES 2005).

Every identity preservation system entails additional costs. Such systems are thus only employed where higher prices can be obtained for certain quality characteristics. No separation of flows of goods was considered when today's GM crops and the products produced from them were introduced. In contrast, producers and companies wishing to exclude GM have developed systems to reliably ensure that there are no mistakes or mixing. This means that today it is the companies which exclude genetic modification from their food production processes who incur the costs.

The available information on the costs to the food industry for excluding GM bears out increase of costs. However, this information is not sufficient for making precise statements regarding the magnitude of the expected costs. This is primarily due to the lack of publicly accessible data on the additional costs of excluding GM from the field to the plate, as

- the additional costs for excluding GM have so far been assessed mainly on the farm level (agronomic co-existence)
- food producers rarely divulge precise data concerning their costs, and thus their pricing, to third parties
- there has been very little research on the whole chain from the field to the consumer.

What is the impact of raw material prices?

Raw materials for food production that are obtained from non-GM production processes are more expensive than conventional or GM commodities. The additional expense for the producers is compensated by a price premium, thus creating a stimulus not to grow GM crops. In the literature, however, there are different statements regarding the magnitude of these price differences. AGES (2005) determined for meat production, additional costs may amount to 8% when the price for the non-GM soya extraction meal used as a feedstuff is 16% above the price for conventional soya meal.

Contrarily, Brookes (2006) assumes that currently the costs of excluding GM doe not yet lead to higher priced final products. However, Brookes worked with low raw materials prices and used a highly simplified method to calculate the extra costs. He determined the additional costs to the producers from the prices for raw materials and the percentages of these raw materials in the finished product. The costs for separation of the flow of goods and quality assurance, however, were not taken into account.

To conclude, the measures discussed above result in additional efforts for the company in terms of management and cannot always be assigned to production costs. Many measures represent an additional cost factor, but are nevertheless essential at certain points of production in order to assure quality. Moder (2004) finds increases of 40% in production costs and 10% in costs for inspection and analysis.

Because there are no available data, the costs incurred in the event the measures fail are unknown. It can be assumed, however, that the costs to a company will increase in direct proportion to the time it takes to discover the failure of a measure. As there is no insurance at the present time to cover contamination risks, the costs for insurance premiums are likewise unknown.

Costs for excluding GM in food production are predominantly incurred by those producers who process non-GM commodities. If GM exclusion becomes more complex in the future as GM crop production expands (AGES 2005), non-GM finished products may become more expensive. Companies have various options for dealing with this:

- They can charge more for products produced without using GM.
- GM exclusion in the future can be limited to the premium product area.

In principle, it can be expected that, as the production of GM crops increases, the availability of unmodified products will decrease and the market will change in the following ways:

- More contract farming
- Increasing prices
- Monitoring along the entire production chain from field to plate
- Substitution of critical components

Companies wishing to refrain from using GMOs in their products in the long term will have to consider how they can secure their supplies in future.

3 Methodology

The cost calculation model for traceability and co-existence measures follows the principle to aggregate all costs for cultivating and transportation of crops or processing of the raw material crops on the different levels and to increase the price of the finally processed product at each level: the commodity price e. g. for maize is increased by the costs of co-existence measures on the farm level in order to comply with the compulsory threshold for adventitious presence of GM material. The resulting price for non-GM maize on farm level is automatically the non-GM commodity price in the next level of the value chain (e. g. the elevator). This principle is used at all stages of the value chain thus aggregating the additional costs for respecting the threshold of GM adventitious presence on all levels and setting the price for the non-GM product at the end of the value chain. In general, the additional co-existence and traceability costs are only referring to the final food product of the value chain and do not consider any by-products which might be produced (e. g. maize gluten for forage production).

For calculating the traceability and co-existence costs an MS-Excel-based simulation model has been developed which includes the potential cost categories at each level of the value chain.

The generation and execution of the model is based on the following impacts:

- Provision of a universally adaptable calculation model for all supply chains and applications (food/feed).
- The single cost types and calculation methodology are based on results of WP2 of the Co-Extra project.
- Quantitative and qualitative data gathered from stakeholder interviews and existing published data sources are used for quantifying co-existence and traceability costs.
- Essential hypothetical presumptions are linked with strategy differentiations („adjusting screws“), qualitative evaluations of stakeholders or comparable data from other surveyed supply chains (wheat starch, rapeseed oil, beet sugar, etc.).

In order to ensure the co-existence (on defined thresholds) between GM and non-GM maize seeds or maize crops the following measures (and resulting cost positions) have been taken into account for the model (Partly gathered from Messéan et al, 2006; Menrad and Reitmeier, 2006; Tolstrup et al., 2003; Bock et al., 2002):

- Cleaning of machinery and equipment when shifting from GM to non-GM fields
- Increasing isolation distances between GM and non-GM crops
- Time isolation: Separating flowering times by providing a choice of varieties, some flowering earlier than others
- Non-GM buffer zone: Sowing of an area of non-GM crops all around the GM field
- Discard width: The discard width of a non-GM field is an area of variable size around the edge of the field that is not included in the final harvest

- Monitoring activities of fields can include testing of the seeds or agricultural crops (via PCR or protein-based analytical quick tests)
- Costs of administration and certification or additional efforts for organizing seed multiplying
- Building of additional storage facilities
- Additional transportation costs (e. g. due to increased transport distances of agricultural crops)
- Other costs (e. g. for training or stewardship programmes of farmers).

On the elevator, crusher (milling) or processor level the main risks are admixture of GM and non-GM commodity or derived products mainly due to human errors (Hirzinger, 2008). In this context it has to be taken into account that Regulation (EC) No. 178/2002 of the EU requires the traceability of food ingredients in the German food industry since 2005. Thus, food industry companies have already installed general documentation and traceability systems which can be used for traceability of GMOs as well without causing additional significant costs for documentation (Hirzinger, 2008; BLL, 2006). Thus, the following measures (and resulting cost positions) have been considered in the calculation model of traceability and co-existence costs for elevators, crushers or processors:

- Higher commodity costs representing the accumulated co-existence and traceability costs of the previous levels of the value chain (also higher extra transport costs due to longer distances as a result of separation of production facilities can occur)
- Higher additional transport costs can occur due to longer transportation distances as a result of separation of production facilities
- Testing programmes for incoming commodity and/or the produced products
- Mode of transport of commodities and produced goods (e. g. via ship or truck) which influence the testing regime and costs of testing programmes
- In the case in which GM and non-GM commodities are handled or processed in the same factory, measures have to be taken for manual cleaning or flushing of the repositories and periphery and adjustment of the production
- Building of additional storage facilities, investments in other additional equipment or building of a complete second production line in an existing plant
- Education and training programmes, e. g. for workers
- Other costs (e.g. for external audits, modifications in organization, certification).

In order to specify and quantify the different cost categories, numerous data and information sources have been used. The costs of co-existence measures at the seed production and farm level have been calculated according to the methodologies used in previous studies or by using a methodological guidebook for calculating costs of co-existence measures which was developed in the context of the EU-funded SIGMEA project and continuously processed for national investigation (Menrad and Reitmeier, 2006). Data from scientific literature or previous research projects were used to quantify the co-existence costs in seed and agricultural production and appropriate co-existence measures have been defined.

Concerning co-existence and traceability costs on elevator or processor level hardly any studies are available for European countries which quantify the costs on these processing levels of the value chain. Thus, specific formula have been developed for each relevant cost type in order to quantify the respective position and finally sum up the costs per unit (in general tons of produced product) to get a price for the final product in a respective level of the value chain. In the following example the formula for commodity, certification and extra transport costs on the elevator or processor level is presented:

[illegible]

PK_A	GM prevention cost commodity, extra transport and certification
$Mp_{non\text{-}GM}$	Amount of processed non-GM commodities in tons
$Mt_{non\text{-}GM}$	Amount of transported non-GM commodities in tons
$p_{non\text{-}GM}$	Price of non-GM commodity in €
p_{GM}	Price of GM commodity in €
t_{GM}	Transport costs due to co-existence in €
$t_{non\text{-}GM}$	Transport costs without segregation in €
K_Z	Facultative costs of certification in € (per year)

Data collection

Data to specify and quantify the different cost types have been gathered empirically using published scientific reports and literature. From 2006 on up to now, expert interviews with stakeholders representing the respective case study to be analysed were conducted in all case study countries. During the process of primary data collection certain limitations were faced which are due to the fact that some stakeholders had i) limited knowledge about the issue of concern and ii) were not willing to cooperate and provide information. Thus partners used an exhaustive literature review, experts' consultations for similar or neighbouring areas in order to compile sound data sets.

In the case that relevant information is lacking in the data set, assumptions were made, based on the situation either in other countries or in comparable value chains. In order to consider the variety of the different situations in the single companies of the analysed value chain, several 'adjustment screws' (like e. g. the threshold of GM adventitious presence in non-GM seed, penetration of GM varieties in agriculture, the strategy to ensure co-existence adopted by an elevator or processor) have been included in the model which allows to simulate the cost structure depending on the assumptions made for the respective factor. These factors can be modified according to the given situation (or meaningful assumptions) and the impact of such changes on the overall traceability and co-existence costs at the level of the final product can be simulated.

4 Case Studies

4.1 Cost and benefits of co-existence in grain maize supply chains: Switzerland

4.1.1 Supply Chain Description

The Swiss supply chain description and the data of the cost calculation are based on stakeholder interviews, secondary information and on official statistics. Gaps of information identified were closed by conducting key-informant interviews with representatives from following areas: feed mill (1), advisors (3), Governmental Statistics Agency (1), Swiss Federal Office for Health (1), Swiss Federal Office for Agriculture (1), Federal Custom Office (1), Farmer Association (2), Processing association (2). All the interviews were conducted personally and lasted between 2 and 4 hours. For the interviews a questionnaire was designed and all interviews were recorded and documented.

In Switzerland, in 2007, the agricultural area amounted 1,060,278 ha which is managed by 59,742 farmers (SBV, 2008). Organic agriculture is quite relevant to the Swiss agricultural sector. Indeed, 10.5% of the farms are managed organically which represent 10.7% of the total agricultural area. More than 60% of the agricultural area is grassland. Grain maize is cropped on 19,106 ha of which 290 ha are organic grain maize (see table 5). So far, no GMO-maize is produced in Switzerland. Maize in Switzerland is used as feed for all farm animals. Maize gluten with 60% raw protein is a by-product of maize and an important food component mainly for dairy cows; fattening cattle; laying hens. There is no production of maize gluten in Switzerland. Gluten is exclusively imported.

Maize production and foreign trade 2004
Due to the topography, soil and climate conditions in Switzerland maize production is limited to certain areas as illustrated in Figure 1. As distances are quite short in Switzerland, transport of goods is not a critical aspect.

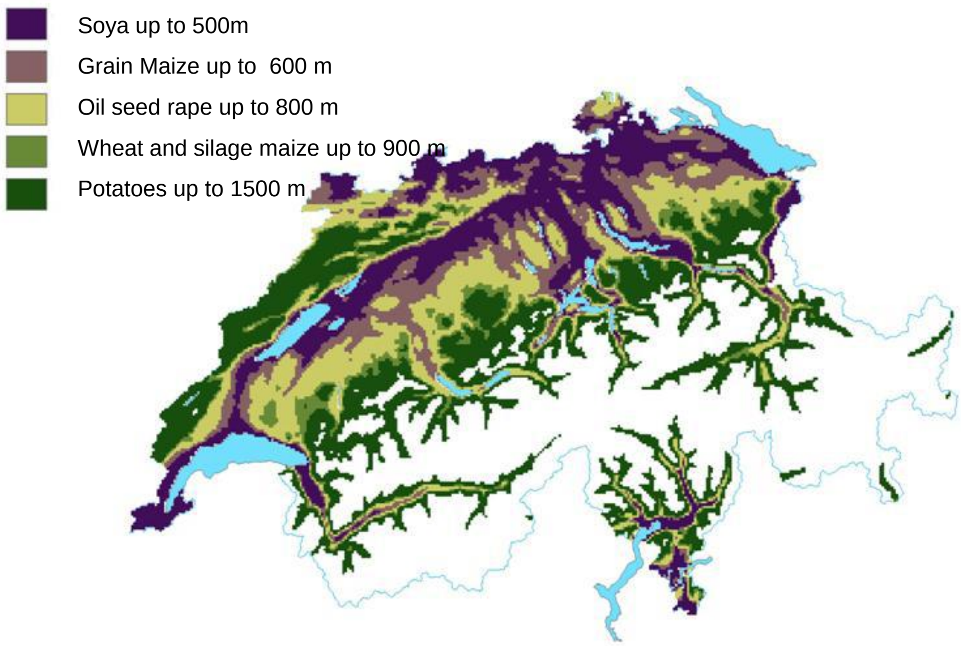


Figure 1: Cultivation of soya, grain maize, oil seed rape, wheat, silage maize and potatoes in Switzerland.

Table 5: Area, production, price, export, import, number of farms cultivating grain maize in Switzerland (2004)

	CONVENTIONAL	**ORGANIC**	**GVO**
Area (ha)	18'816	290	0
Production CH (t)	180'600 (1)	n.d.	0
Export (t)	206 (2)	n.d.	0
Import (t)	79'305 (2)	1'831	23.8
Farms cultivating grain maize	7'628	161	0

(1)Provisional; (2) except maize gluten; n.d. = no data available

Sources: BLW, 2005; Bundesamt für Statistik, 2004; EZV, 2004; LBL, 2004; Rudmann and Willer, 2005

Conventional maize feed is mainly imported from Brasil, France and Hungary; Maize gluten from U.S.A., France and Germany. Organic maize is mainly imported from Germany, Italy and Hungary (Bio Suisse, 2006).

Export of conventional maize has a very little importance in Switzerland. Organic maize is not exported at all.

4.1.2 Case study results

Seed production

In Switzerland, seed maize is produced on around 250 ha. About two third of the total maize seed used in Switzerland is imported maize seed. As there is no GM maize traded in Switzerland, no information is available about the additional costs of guaranteed non-GM maize seeds and potential technology fees for GM maize seeds in Switzerland.

The cost estimations for guaranteed non-GM maize seed is based on arguments of analogy from organic seed production. According to AGRIDEA (2007), the costs for maize grain amounts 127.3 €/unit compared to 94.7€/unit of certified conventional maize grain seed. This corresponds to additional seed costs for certified organic maize seeds of 34.4%. Working on the assumption of similar prevention and segregation costs of organic and guaranteed non-GM maize seed production and taking a 20% lower organic yield into account, we assume for the Swiss case study additional seed costs for non-GM seeds of 12 % per unit.

Regarding additional costs for GM maize seed we rely on Kasamba and Copeland (2007) who considered for the calculation of farmer's co-existence costs a Technology Use Agreement. Reitmeier et al. (2006) found for Germany additional costs of 34% for Bt maize seed. For Spain, Gómez-Barbero and Rodruigez-Cerezo (2007) report additional Bt maize seed costs of 6.96€/ha to 37.79€/ha which corresponds to additional costs of 4 – 21%. For the Swiss case study, we assume a technology fee for Bt maize seed of 20% on top of the conventional maize seed price.

Farm level

F-A. Gross margin grain maize: production costs:

Between 1995 and 2007, the average grain maize yield in Switzerland amounted 9.3 t/ha (SBV, 2008). For Bt maize, Degenhardt et al. (2003) reported a yield boost for Bt maize in South Germany of 12.5%. For the Swiss case study we consider a yield boost of 10%.

According to AGRIDEA (2007), in 2006, the producer price for grain maize in Switzerland was 286.7€/t. For our cost calculations we assume for Bt maize that producer prices will not decrease below the current average conventional grain maize producer price and consider therefore a producer price of 286.7€/t. As far as IP non-GM grain maize is concerned, we assume a price premium due to higher co-existence costs and lower trader and consumer acceptance of GM products. However, IP grain maize price premium is expected to be considerably lower than the organic grain maize price premium which was 80.2 % in 2006 (AGRIDEA, 2007). In Switzerland, IP-Suisse commodities represent a market segment with quality standards between conventional agriculture and organic farming standards. As the IP-Suisse food label guarantees non-GM production, we base our price assumption on the average IP Suisse price premia of 16% (IP-Suisse, 2009).

One of the incentives for adopting Bt maize is reduced insecticide treatments costs against the European Corn Borer. In Switzerland, the dominant strategy against the Corn Borer is the use of Trichogramma. The Trichogramma treatment in IP grain maize is assumed to cost 100.3€/ha including labour costs (AGRIDEA, 2007). Hail insurance amounts to 3.4 % of the total return (AGRIDEA, 2007). Due to a higher total return for IP grain maize, the actual hail insurance costs are higher with the IP grain maize compared to the GM maize. The total additional costs for IP non-GM grain maize production of 90.6€/ha therefore result from the additional Trichogramma treatments (100.3€/ha), the additional hail insurance costs (+5.4€/ha) and the lower IP maize seed costs (-15.1€/ha).

F-B. Cleaning the machinery

In Switzerland, farmers use hired machinery for sowing maize and for maize harvest. As the harvesting period does not allow for the non-use of sowing machinery and harvester combines for cleaning, we assume that there will be separate machinery for GM and non-GM maize which in turn will result in a lower capacity use and therefore higher hiring costs of harvesters. However, the capacity use depends on the share of GM and non-GM grain maize areas in a region which at this stage cannot be determined. According to the results of the SIGMEA project, the lower capacity use will increase the costs for hired machinery equally for both IP and Bt maize producers to 32.5€/ha (Copeland et al., 2007).

F-C. Costs of time isolation

No such costs are expected.

F-D. Discard width on the non-GM field – opportunity costs

To ensure co-existence of Bt grain maize and non-GM grain maize, we consider a discard zone of 100m. Following the approach implemented in the SIGMEA project, the discard zone will be on the non-GM field. With a non-GM field size of 1.3ha and a 100m discard zone, the corresponding discard zone area amounts 1.1ha. Considering a difference in the gross margin between non-GM and GM grain maize of 69.4€/ha and additional transaction costs of 5.3 €/ha, the total opportunity costs related to the discard zone area is calculated with 64.9€/ha

F-E. Non-GMO buffer zone on the GM field-extra sowing

No additional costs are expected due to the used isolation strategy with discard zones (see F-D).

F-F. Monitoring costs

Analogously, to the discard zone cropping strategy, we consider the non-GM farmer to be responsible for ensuring IP produce. As a consequence, monitoring costs are with the non-GM farmer. We assume one qualitative test (with costs of 125€/test) per truck and 0.5 hours additional labour requirements (28€/h). This will result in additional monitoring costs of 51.5€/ha.

F-G. Depreciation for additional storage and infrastructure caused of parallel production

For the Swiss situation, we do not expect parallel production of GM and non-GM grain maize on the same farm. Therefore, we do not consider any additional costs for storage and infrastructure at farm level.

F-H. Possible additional transport costs to the next level (cleaning)

As monitoring is assumed to be done on the truck during transport to the elevator with farmer's own machinery, only those trucks would need to be cleaned which transported a positive tested harvest. However, positive tested harvests are subject of system failure against which the non-

GM farmer will insure himself. The additional costs for indicative insurance are included in section F-G. Miscellaneous costs. Therefore, no additional transport costs are expected.

F-J. Costs of administration/certification

No extra costs are appointed for administration and certification.

F-G. Miscellaneous costs

As already mentioned in section F-H., we expect farmers to insure themselves for system failure or contamination risk respectively. This indicative insurance is assumed to cover all extra costs as additional cleaning of transport and storage facilities, transaction costs etc. The insurance costs are estimated to amount 20.20€/ha.

<u>Executive Summary</u>

Table 6 shows the total costs at farm level in Switzerland

Table 6: Cost calculation at farm level (Switzerland)

Farm level - F		Additional costs	
		€	%
A. Additional production costs non-GMO	€/ha	90.6	39.9
B. Cleaning costs	€/ha	0.00	0
C. Costs of time isolation	€/ha	0.00	0
D. Costs of discard width (non-GMO)	€/ha	64.9	28.6
E. Costs of buffer zones (GMO)	€/ha	0.00	0
F. Monitoring costs	€/ha	51.5	22.6
G. Depreciation for additional storage	€/ha	0.00	0
H. Possible additional transport costs	€/ha	0.00	0
I. Costs of administration/certification	€/ha	0.00	0
J. Miscellaneous costs	€/ha	20.20	8.9
TOTAL	**€/ha**	**227.2**	**100.0**
TOTAL	**€/t**	**24.4**	

The calculations show that the additional co-existence costs of grain maize at the farm level in Switzerland amount to 227.2€/ha or 24.4€/t respectively. The most relevant costs are the costs are the additional production costs for non-GM grain maize which amount to 39.9% of the total additional costs. Around 29% of total costs are related to costs of discard width while 22.6% of the co-existence costs are related to monitoring costs.

Elevator

At elevator level it is a realistic co-existence scenario that elevators will specialize either to GM or non-GM products once co-existence becomes reality. In Switzerland this situation was already discussed with stakeholders and other experts for the production of organic and conventional commodities. Background is that the organic animal feed in Switzerland has to be processed separately beginning with the year 2010. The expected costs for the elevator level are described below. Firstly, the interviewed elevator (named Elevator A) which is used as an example is described shortly. For more detailed information about this elevator see Deliverable 2.3 of Workpackage 2 of the Co-Extra project.

Portrait of Elevator A

The elevator interviewed is organized as a cooperative of farmers with 450 members. The cooperative itself is a member of the fenaco Group. The company is one of the ten biggest collecting points in the fenaco network. The enterprise's total storage capacity amounts to 5,000t. The delivery of maize grain for feed is 1,000 t/a. The storage capacity consists of 20 silo cells (3 cells à 400t, 3 cells à 250t, 14 cells à 90-120 t) and is equipped with a central drying facility.

So far no GM-maize is delivered to this elevator. Thus the company only deals with non-GM products. Commodities are only delivered from Swiss origin. Even though, the company does not have any objection against GM-crops and sees some cost reducing advantages for farmers, GM-crops are not seen as a product for the Swiss market and estimation of the corresponding risks are not available so far. Thus in mid-term, GM-crops are not expected to become relevant for the company. Through contracts with the collecting point, farmers are obliged to confirm to deliver only non-GM commodities and to use only non-GM seeds. From every delivery of a single farmer the collecting point takes a sub-sample.

According to the information of the plant manager, the current elevator's facilities and infrastructure would not allow for segregation of GM and non-GM maize. As a consequence, parallel operation of GM and non-GM commodities would require investments in a separate delivery, loading, drying and storage facility. At the moment, such an investment would be a serious economic burden to elevators.

Against the background that from 2010, in Switzerland organic livestock feed is required to be processed separately, cost efficient segregation strategies have already been subject of intense discussions between stakeholders. Due to the small scaled structure of the Swiss elevator sector, stakeholders expect local segregation in form of specialized elevators to become the most promising co-existence strategy.

For the co-existence scenario, we assume analogously local segregation: elevators specialize in either operating GM or non-GM commodities.

E-A. Commodity, certification and extra transport costs

The farm level borne prevention costs for IP grain maize will cause additional commodity costs of a total of 24,431 € for the elevator plant operating annually 1,000 t of grain maize. Even though, the elevator network is quite dense in Switzerland, transport costs will increase due to the local specialisation strategy. Assuming additional transport distances of 2 x 50km and transport costs of 0.1€/km and ton, the aggregated total additional commodity costs for IP non-GM grain maize amount 34,431 €.

E-B. Form of transport and transport testing costs

Qualitative test during transport from the field to the elevator are to be covered by the non-GM farmers and thus already included in the additional costs at farm level. From every incoming truck a sub sample is taken. Due to the fact that taking sub samples from every incoming truck is already implemented, this will not cause any additional costs under a co-existence scenario. However, every truck leaving the elevator will be tested using quantitative PCR-Analysis (187.5 € per test; 0.5 h additional labor). This results in total testing costs of 7,500 €.

E-C. Depreciation for additional storage and infrastructure caused by parallel production

With a local segregation strategy, no investments are required at the elevator's level.

E-D. Cleaning (Flushing) repositories

Again, as GM and non-GM grain maize is stored separately, no additional cleaning or flushing costs are considered.

E-E. Possible additional transport costs to the next level (cleaning)

In order to ensure, that none of the trucks transporting IP grain maize to next level is contaminated, each truck will need be to be cleaned prior to loading. The resulting cleaning costs amount 1,400€.

E-F. Miscellaneous costs

No other costs are considered.

Executive summary

The total prevention costs for IP grain maize under a local segregation strategy amount 43,331 € for an elevator plant operating annually 1,000 t IP grain maize (Table 7).

Table 7: Total costs of co-existence at elevator level (Switzerland)

Elevator - E			
A. Additional commodity costs	34.4	€ per ton	*79.5%*
B. Testing costs	7.5	€ per ton	*17.3%*
C. Depreciation of add. storage	---		---
D. Cleaning/Flushing costs	---		---
E. Possible add. transport costs	1.40	€ per ton	*3.2%*
F. Miscellaneous costs	---		---
Total prevention costs	**43.3**	**€ per ton**	***100.0%***
Prevention costs for the regarded company	**43,331**	**€**	
Share prevention costs in % of turnover	**10.1**	**%**	

The most relevant costs are the additional commodity costs which amount to 34.4 €/t or 79.5% of the total prevention costs respectively. Although, a quantitative test is taken from each truck loading IP grain maize, the testing costs are with 7.50 €/t (17.3%) rather low. The costs for cleaning trucks prior to loading are around 3.2% of the total prevention costs. The share of prevention costs on the total IP maize grain turnover amounts 10.1%. As a consequence, the additional co-existence costs might lead to increasing prices for IP grain maize of around 43.3 €/t. With a basic price franco crusher of 387.3 €/t (AGRIDEA, 2007), the non-GM grain maize price is estimated to amount 430.6 €/t for the next supply chain level.

Crusher/Feed Mill

Contrarily to the situation at elevator level, in Switzerland, there was a concentration process at feed mill level. Currently, there are around 200 feed mills which process and deliver raw material or processed feed respectively in the whole of Switzerland.

Crusher A

The company is member of the fenaco group. It produces feed for the fenaco group as well as for its own brand. It produces annually 30,000t of mixed feed for which 1,500t grain maize is required. There are 13 persons employed at the company. The company only processes feed and therefore does not act as a collection point and does not provide any storage capacity for raw material nor for processed feed. The company produces just in time. The commodity is delivered by truck or by train. Delivery to the mill by train takes place only for cereals. 90% of the commodity is delivered by trucks to the clients.

The plant processes feed of different qualities: common animal feed, medical animal feed and special animal feed (e.g. for horses). Even though different feed qualities are processed, the plant manager states that parallel processing of GM and non-GM qualities would not be possilbe. Under a co-existence scenario, the plant would run a local segregation strategy.

80 % of the raw material is supplied by fenaco. The remaining 20 % is delivered by other clients. The import of the raw material is also managed by two Swiss specialised bureaus.

The GM-threshold is 0.9 % but the aim is no contamination with GMO at all (not detectable). The commodity delivered by fenaco is checked by the assurance quality system of fenaco and is anticipated to be GMO-free. Fenaco carries out GMO-tests by its own laboratory. Additionally samples are taken. So far, none of these samples was tested positive. Storing sub-samples is standard.

C-A. Commodity, certification and extra transport costs

According to AGRIDEA (2007), the price franco feed mill for grain maize amounts 387.3 €/t. The corresponding IP grain maize price is loaded with the additional prevention costs from the previous supply chain level (43.3 €/t) and is thus estimated to amount 430.6 €/t.

According to the stated local segregation strategy of Crusher A, GM and non-GM maize are not processed on the same plant. Therefore, additional transport costs are expected under a co-existence scenario. Analogously to the calculation of additional transport costs at the elevator level, we assume additional transport costs of 0.1 €/km and ton. The additional transport distance at the feed mill level is estimated to amount 100 km. The total additional commodity costs amount therefore 95,002 €.

C-B. Form of transport and transport testing costs

Produce is mainly delivered by train or truck respectively. As the plant does not have any storage capacity, the company runs a continuous delivery strategy.

80% of the IP maize processed is delivered from the fenaco group's own elevator companies (see portrait of elevator) and is already tested prior to loading at the elevator' plant. 20% of the grain maize however is delivered from other clients. The feed mill requires certificates of quantitative testing prior to unloading at the feed mill's plant. These quantitative testing costs are included in the prevention costs of the elevator. Each income delivery therefore will only be tested using a quick test (5€ per test; 0,25 h additional labour). As already implemented common procedure for all deliveries, a sub sample is taken. The latter does not imply additional prevention costs. However, all processed and out-going IP products are tested using a quantitative PCR-Test (187.5 € per test) prior to loading. The total testing costs amount 14,100 €.

C-C. Depreciation for additional storage and infrastructure

As the company will not process GM and non-GM products in parallel, no additional investments to comply with co-existence rules are required.

C-D. Cleaning (Flushing) repositories

No additional cleaning costs need to be included as the plant only processes non-GM commodities.

C-E. Possible production stop costs due to cleaning production infrastructure

Production stop due to cleaning the entire plant is an annual procedure which is done in any way and causes therefore no additional prevention costs.

C-F. Education and training costs

The staff employed requires being capable to operate very different qualities. Therefore, staff is trained on a regular basis. Thus, no additional training costs are expected.

C-G. Miscellaneous costs

There are no further costs considered.

<u>Executive Summary</u>

The aggregated prevention costs calculated for the grain maize case study in Switzerland amount to a total of 109,102 € at the feed mill level (see table 8).

Table 8: Total co-existence costs of non-GM grain maize at feed mill level (Switzerland)

Crusher - C			
A. Additional commodity costs	75.3	€ per ton	*87.1%*
B. Testing costs	11.2	€ per ton	*12.9%*
C. Depreciation of add. storage	---	€ per ton	---
D. Cleaning/Flushing costs	---	€ per ton	---
E. Production stop costs	---	€ per ton	---
F. Education and training	---	€ per ton	---
G. Miscellaneous costs	---	€ per ton	---
Total prevention costs	**86.5**	**€ per ton**	***100.0%***
Prevention costs for the regarded company	**109,102**	**€**	

Again, the most relevant costs are the additional commodity costs which take a share of the total prevention costs of 87%. With a share of almost 13%, testing costs are by far less important to the total prevention costs.

4.2 Costs and benefits of segregation and traceability between genetically modified (Bt-) maize and non-GM maize starch supply chains (Germany)

The aim of this case study is to quantify the costs of traceability and co-existence systems for the maize starch supply chain from the seed to the food (feed) levels in Germany respecting EU legislation thresholds for labelling of GM food. Special emphasis is laid on the GM prevention cost structure by growing maize as commodity crop for food products and starch production and on additional costs occurring in the elevator and processing levels of maize starch production. Aggregating the emerged costs in all levels of the supply chain shows the total co-existence and traceability costs and gives a reference for the higher price level of non-GM maize starch in the case of co-existent production.

4.2.1 Utilisation of starch and modified starch in food products

This case study focuses on the issue of co-existence of GM and non-GM maize in human food (TransGen Wissenschaftskommunikation, 2009b). Therefore, an overview of the utilisation of (maize) starch in food and beverages shall point out the importance of the starch as commodity in the food sector. Starch is processed in several forms and modifications in innumerable food products as binding material, carrier or filler substance:

- Pudding, instant soups, sauces
- Bakery products, infant food
- Fruit additives for curds, yogurt, desserts, ice-creams etc.
- Mayonnaise and tomato ketchup
- Conserved food products (e.g. canned fish)
- Miscellaneous convenience-oriented food products, deep-frozen food and dairy products
- Raw material for products of starch saccharification like glucose molasses, isoglucose
- Non-Food sector: bioplastics and rapid biodegradable products (e. g. eatable dishes, children's toys).

Today, starch can be defined as „universal commodity“. Starch products are present in nearly all areas of life (Ziermann, 2001). Thus, there hardly exist any food products without including starch or starch derivatives. The modern society with its current life and consumption habits has new demands for food products and food processing. Rapid and easy preparation, rigidity and storage life, enhancement of taste and flavour, agreeable appearance and the promotion of modern imagination of nutrition can be defined as so called „convenience“-products. Starch with its diversified properties becomes a key role for the development and production of such products.

Maize starch can be transformed to glucose syrup by saccharification. Glucose syrup is used as ingredient for numerous food products and beverages and is the most meaningful product in starch saccharification. Hereby, the most important commodity is maize starch but in Europe also potato and wheat starch are processed. The ingredient “Glucose syrup” is offered in several varieties with different sweetening power and technological attributes like consistency and viscosity. Compared to traditional sugar, glucose syrup has different physical properties and does not crystallize out so easily. In a further step (isomerisation), the glucose can be completely transformed to fructose. This sugar owns an increased sweetening power. In the USA, this “High Fructose Corn Syrup” is nearly completely processed based on maize starch. It has replaced the traditional sugar in many areas, e. g. lemonades and fresh beverages.

In Germany glucose syrup substitutes partly or completely the traditional sugar in many food products like confectionery, bakery products, desserts, non-alcoholic beverages, canned fruits and vegetables, frozen products etc.

Altogether, more than two third of the worldwide harvested maize is used for animal feed. In contrary to the maize grown for food and industrial processing, silo maize is grown for animal feeding and the whole maize-cob is chaffed and processed. Products based on maize in the food supply chain only fall back on the maize kernels. In recent years maize is more and more used as energy plant and renewable resource in biogas fermentation plants for generating heat and electricity or for the production of fuel (bio ethanol). New maize varieties are optimized for biomass production. Other parts of the maize plant can be used for products like oil binding agents, pet bedding or bio-compostable filling or packing material.

Currently maize is genetically modified with respect to the following targets (TransGen Wissenschaftskommunikation, 2009a):

- Improved cultivation attributes
- Weed management (herbicide tolerant plants)
- Disease and pest tolerances and resistances
- Acclimatisation to changed climate and local factors
- Modified starch composition
- Production of pharmaceutical agents
- Generating new starch derivatives for novel bioplastics
- “Molecular pharming”: Use of GM maize for the production of technical enzymes or pharmaceutical substances
- Generation of heat-resistant alpha-amylase in maize kernels for a better exposure of maize starch and therefore an increased effectiveness in bio ethanol processing. One heat-tolerant GM maize variety is currently in the EU approval procedure.

In the following chapters the occurring economical benefits (e. g. loss of insecticides, yield effects) and efforts (e. g. costs of seed and changed field practices) of Bt- maize versus conventional maize production are more specified and applied on national basic parameters in Germany.

4.2.2 Maize starch production – German case study

The focus of this case study is set on maize starch food products and therefore statistical data concerning sweet maize and silo maize production are not considered in the further analyses.

As shown in table 9 only a very limited amount of base and certified maize seeds are produced in Germany mainly due to climatic reasons which allow maize grain production only in few regions of Germany. Most of the certified seeds used in maize production in Germany are imported from France, Italy and other countries.

Table 9: Level of maize seed production in Germany (base and certified seeds)

Year	Level of maize seed production (ha)	Percentage certified seed
2001	2,549	97.5 %
2002	2,742	96.9 %
2003	3,108	98.1 %
2004	3,164	96.7 %
2005	3,309	96.6 %
2006	2,383	-
2007	2,754	97.1 %

Source: BMELV (2007)

The acreage of grain maize crop production in Germany was around 440.000 ha in 2005 (see table 10). Almost 4.1 million tons of grain maize was harvested on this cultivation area (BMELV, 2007).

Table 10: Grain maize production in the EU

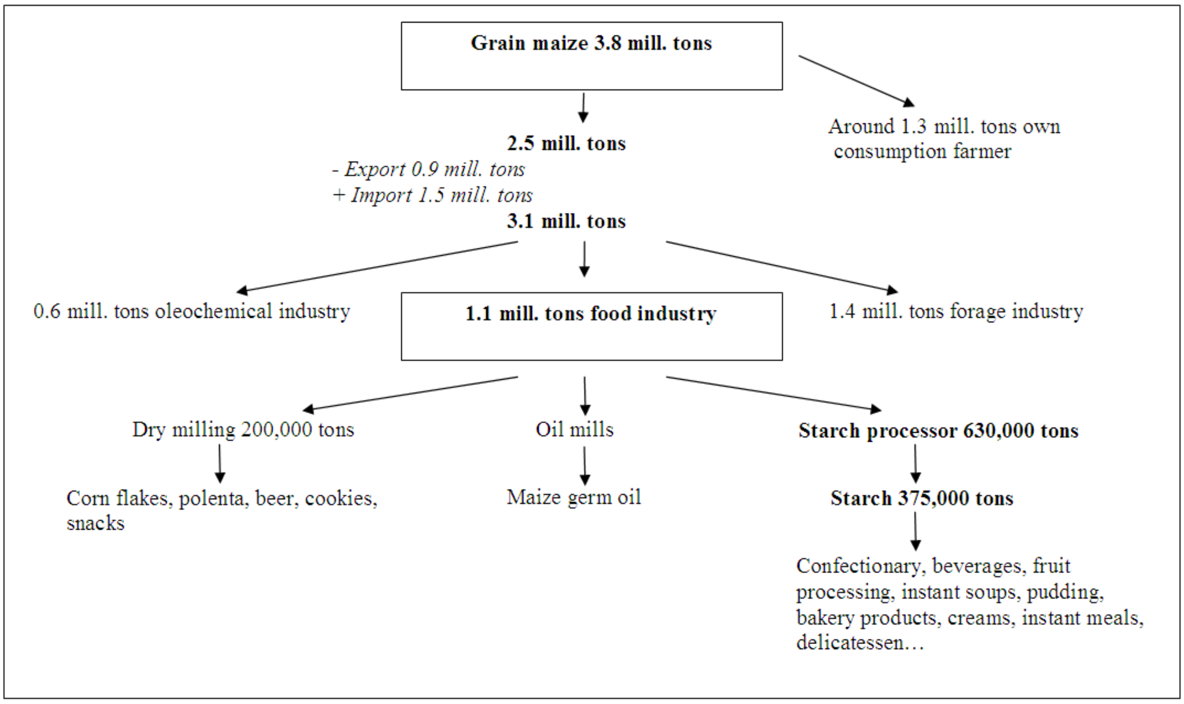
Rank	Country EU	Acreage		Yield		Amount				
		2005	2006	2005	2006	2002	2003	2004	2005	2006
		1,000 ha		quintal per ha		1,000 tons				
		Maize (without silo maize)								
1	FRA	1,655	1,503	83.7	85.5	16,440	12,045	16,372	13,850	12,853
2	ITA	1,119	1,108	93.9	87.3	10,554	8,702	11,367	10,510	9,671
3	ROM	2,592	2,484	40.1	36.2	8,400	9,577	14,542	10,388	8,985
4	HUN	1,198	1,229	75.6	68.7	6,121	4,532	8,332	9,050	8,441
5	**GER**	**443**	**401**	**92.1**	**80.3**	**3,738**	**3,422**	**4,200**	**4,083**	**3,220**
	EU - 27	**8,950**	**8,545**	**70.3**	**.**	**59,992**	**52,287**	**71,445**	**62,958**	**55,478**

Source: BMELV, 2007

Production of starch and starch derivatives in Germany

It is shown in figure 2 that – imports, exports and farmers' own consumption were considered as well – around 3.1 million tons of grain maize are transferred into further processing. 1.4 million tons are used in the forage industry, 0.6 million tons in the oleo-chemical industry and 1.1 million tons of grain maize are available for food production. The biggest part out of it is claimed by the starch processors with 630,000 tons and a rate of yield of 375,000 tons of starch. A smaller percentage of the grain maize food production implies the dry milling industry with products like cornflakes or snacks with around 200,000 tons.

Figure 2: Flow chart: Maize for food production in Germany



Source: Stratmann et al (2006) cited in Gawron and Theuvsen (2007)

Starch is the universal substance for energy storage of plants and is mainly stored in tuber, roots and seeds (TransGen Wissenschaftskommunikation, 2009b). It is the predominant carbohydrate in human food. Chemically it is defined with bigger, partly chain like sugar molecules (polysaccharides). In Germany starch is predominantly processed out of potatoes. Maize and wheat play a less important role. In the EU where 9.6 million tons of starch was produced in 2005, maize starch is the mostly processed commodity with a proportion of 46 % in 2005 (wheat starch: 36 %, potato starch 18 %) (table 11).

Table 11 German and European starch industry

	Germany			Europe		
Year	**1998**	**2001**	**2005**	**1998**	**2001**	**2005**
Turnover	1.0 bn. €	1.1 bn. €	1.2 bn. €	5.2 bn.	6.5 bn.	n.k.
Companies	8	8	8	28	27	24
Factories	16	15	14	75	67	68
Employees (in 1,000)	2.4	2.2	2.2	19.0	17.0	20.0
Processed commodities	**4.5 mill. t**	**4.4 mill. t**	**4.6 mill. t**	**19.1 mill. t**	**21.2 mill. t**	**22.6 mill. t**
Potatoes	66 %	66 %	65 %	46 %	41 %	38.4 %
Maize	16 %	14 %	15 %	31 %	31 %	31.2 %
Wheat	18 %	20 %	20 %	23 %	28 %	30.4 %
Production	**1.5 mill. t**	**1.5 mill. t**	**1.51 mill. t**	**7.7 mill. t**	**9.0 mill. t**	**9.6 mill. t**
Potato starch	40 %	43 %	44 %	22 %	20 %	18 %
Maize starch	31 %	25 %	27 %	49 %	46 %	46 %
Wheat starch	29 %	32 %	29 %	29 %	34 %	36 %
Consumption of starch and derivative starch products	**1.5 mill. t**	**1.6 mill. t**	**1.85 mill. t**	**7.3 mill. t**	**8.3 mill. t**	**9.0 mill. t**
Starch (native)	31 %	28 %	30 %	25 %	23 %	23 %
Starch (modified)	18 %	19 %	18 %	18 %	17 %	20 %
Saccharized products	51 %	53 %	52 %	57 %	60 %	57 %
Consumption of starch products in sectors	**1.5 mill. t**	**1.6 mill. t**	**1.85 mill. t**	**7.3 mill. t**	**8.3 mill. t**	**9.0 mill. t**
Non-Food	***40 %***	***39 %***	***43 %***	***47 %***	***45 %***	***42 %***
Papers & paperboards	23 %	23 %	25 %	27 %	27 %	28 %
Chemical , fermentation and	6 %	7 %	6 %	20 %	18 %	14 %
other technological industry	11 %	9 %	12 %			
Food	***60 %***	***61 %***	***57 %***	***53 %***	***55 %***	***58 %***
Confectionary	20 %	20 %	16 %	24 %	26 %	30 %
Other food industries	40 %	41 %	41 %	29 %	29 %	28 %

Source: Fachverband der Stärke-Industrie (2009), Association des Amidonniers et Féculiers (2009)

4.2.3 Data collection

This report analyses the feasibility and costs of co-existence by GM and non-GM production along the German maize starch supply chain. The information was conducted throughout existing case studies and publications or public information and interviews conducted with experts along the maize starch supply chain. The information used for the cost calculations along the supply chain are shown in table 12.

The following boundaries of the maize starch supply chain are set for this report:

- Start of this supply chain description is the seed producer including the contracted seed farmers

- End of this supply chain description is the maize starch factory

Table 12: Important information gathered for the cost calculation

Chain Level	Information
General	Compulsory conditions and assumed GM situation
Seed producer	Costs of co-existence and economical benefits of GM seed production and processing
Farmer	Costs of co-existence and economical benefits of GM crop production
Elevator	Cost structure and applied strategies of co-existence and traceability
Starch processor	Cost structure and applied strategies of co-existence and traceability

4.2.4 Results of the German case study

Seed production

In the following paragraphs the cost structure at the seed (producer) level is presented (see cost types S-A. – S-G.).

Costs of the technology

In the following paragraph the costs of the applied measures to prevent admixture of GM and non-GM seed following the general EU-regulations of co-existence for seeds are calculated and compiled to achieve non-GM seed within the preset threshold of 0.5%. These costs are then added on the GM seed production price as chargeback of additional prevention measures. This ‘technology fee’ or ‘price premium’ reflects the increase of seed costs of the transgenic variety. For Syngenta’s Compa CB, Brookes (2002) reported a technology fee of 29-31 €/ha in Spain. This price is recommended by the seed industry but many farmers pay lower prices through local co-operatives, i.e. 18-19 €/ha, capturing 70 % of the Spanish maize seed market. In the Czech Republic, a technology fee of 31 €/ha is used. Monsanto CZ claimed that they will use more or less the same technology fee in other EU regions, with a variation of 10 % depending on the region (Reitmeier et al., 2006).

Costs for seed in Germany

Based on a telephone interview with a German seed retailer there are seed charges of 95 € per unit (which is 50,000 seeds) for a Bt-maize variety (Reitmeier et al., 2006). This price is 24 € higher compared to a conventional variety in 2006. This reported extension means a higher price of 34 %. Degenhardt, Horstmann and Mülleder, three product manager of bigger seed companies stated a higher price of 35 € compared to conventional maize seed within their profitability calculation of Bt-maize seed (Degenhardt et al., 2003). With an assumed conventional seed price of 170 € per ha for the farmer (Menrad and Reitmeier, 2006), we imply a technology fee (and additional GM-seed costs) of 20.5 % as base value for the further calculations (table 13).

Table 13: Price estimation for GM seed maize

	Non-GM seed	GM seed (Bt- maize)
Assumed yield of seeds	3.5	3.5
Price (per unit = 50,000 seeds)	170 €	205 €
Price in %	100	120.5
Price per ton	950 €	1,145

Sources: Own investigation based on data of Menrad and Reitmeier (2006) and Degenhardt et al. (2003).

The yields of GM and non-GM seed production are assumed to be the same. The target of breeding new GM varieties is to introduce economic and labour-saving benefits for maize crop production, but higher yields for GM maize seed are not assumed for the cost calculation on seed level. Thus the higher prices for GM seed have to be handed on to the next chain levels. Secondly, it is also assumed that the direct seed production efforts and costs are the same in cultivating both GM and non-GM maize seed (see table 14).

The economic performance of maize seed production in a region of Baden-Württemberg in 2004 is presented in table 14**.** With the assumption of the same yield and 20.5 % higher prices for GM maize seed varieties the total income rises up to 4,007 €/ha. This income coincides with variable production costs of more than 2,000 €/ha, resulting in a gross margin of 1,755 €/ha for conventional certified maize seed production and 2,397 €/ha for Bt-maize.

The income, gross margin and variable costs of the two seed production cases will be used for the following cost calculations of co-existence measures in maize seed production.

Table 14: Economic performance of maize seed production in Baden-Württemberg

Parameter		Baden-Württemberg, South-West Germany	
	Unit	Conventional prod.	Bt- maize
Yield	t/ha	3.5	3.5
Price	€/t	950	1,145
Fodder maize	t/ha	0.4	
Price	€/t	100	
Total income	**€/ha**	**3,365**	**4,007**
Costs of basic seed	€/ha	272	
Plant protection	€/ha	285	
Machinery costs	€/ha	50	
Machinery renting costs	€/ha	300	
Castration (labour costs)	€/ha	530	
Irrigation	€/ha	375	
Charge for acceptance	€/ha	32	
Fertilizer	€/ha	146	
Insurance	€/ha	70	
Variable costs	**€/ha**	**2,060**	
Compensation payments total	€/ha	450	
Gross margin	**€/ha**	**1,755**	**2,397** (excl. prevention costs)

Source: Modified by Menrad and Reitmeier (2006) according to Hugger (2004)

S-A. Cleaning/Flushing costs

In the case of co-existent production, the production and harvesting machinery will have to be cleaned in order to guarantee that no seed traces of other types remain in the machinery. For some types of machinery like harvesters it can be difficult to clean sufficiently. The costs of cleaning storage and field machinery have been - transferred from the calculations on farm level in the Danish co-existence study - estimated to be around 11 € per ha (Tolstrup et al., 2003).

S-B. Costs of time isolation

In order to reduce cross pollination between GM and adjacent non-GM fields, modifying of the flowering times (by cultivating varieties with differing flowering sequences) is suggested as an important co-existence measure in maize seed production. This measure has to be carried out by the GM seed producing farmer. In order to calculate the opportunity costs of this measure, it has to be taken into account that farmers face yield losses if they change to a maize variety with later flowering time. According to published data of Bock et al. (2002) these yield losses amount to more than 13 % in case of changing from a very late to late variety (30 days) and almost 3.5 % in case of changing from a late to a mid early variety (60 days) (table 9). Taking into account the differing yield losses in case of changing flowering times of maize varieties, an income loss amounting to almost 540 €/ha has to be expected in case of changing from a very late to a late variety. This equals to 26.1 % of the variable production costs or 22.4 % of the gross margin of seed production (table 14). In case flowering time is changed from a late to a mid early variety, an income loss of around 137 €/ha can be expected which equals to around 6.7 % of the variable production costs or almost 5.7 % of the gross margin of maize seed production (table 15).

Table 15: Income loss of changing flowering times in maize seed production

Changing flowering time from ….	Very late to late	Late to mid early
Difference in flowering time (°days)	30	60
Yield loss (t/ha)	0.47	0.12
Yield decrease (%)	13.44	3.43
Total income	4,007.0	
Price of Bt-maize seed (€/t)	1,145.0	
Gross margin (€/t)	2,397.0	
Income loss due to change of flowering time (€/ha)	538.54	137.44
.....% of variable production costs	26.1 %	6.7 %
.....% of gross margin	22.4 %	5.7 %

Sources: Calculations of Menrad and Reitmeier (2006) based on data of Bock et al. (2002) and own calculations

Spatial isolation measures (S-C. & S-D.)

Changing isolation distances between fields is a widely used method to control contamination between different varieties in certified seed production. Thus this method will be handled as well when analysing the costs of additional co-existence measures in maize seed production. In this context methodological questions emerge since the distribution of seed-producing fields in a region is generally organised by seed breeding companies (or other companies engaged to organise multiplying of base seed varieties on behalf of seed breeding companies) in co-operation with the farmers who actually do the multiplying of base seed varieties. In this context crop-specific isolation distances between seed-producing and other fields of the same species have to be taken into account which is regulated by international and national regulations.

In order to give an insight in the potential range of costs which might be caused by changing isolation distances between maize seed and/or maize crop producing fields in the maize seed producing region in South-West Germany, a hypothetical model was calculated which can be regarded as a kind of worst case scenario. A squared GM seed field of 5 ha is assumed in this model with adjacent non-GM seed or crop fields of different size. The farmer producing GM seed on this field could be made responsible to change the isolation distance. In this case it is assumed that the GM farmer plants another alternative crop in the increased isolation distance (buffer zone on the GM field). The same effect can be achieved by planting extra male parent rows or alternative crop on a 'discard width' on the border of the non-GM field. In the latter case it is assumed that the costs of these extra male parent rows are compensated by the GM farmer (see figure 3).

Figure 3: Methodology and effects of calculating costs of changing isolation distances in maize seed production

Compulsory isolation distance

S-C. **Planting another crop as isolation area around the GM crop as** ***Buffer zone -extra sowing-***	**S-D.** **Growing alternative crop or planting extra male parent rows on the non-GM field as** ***Discard width -extra harvesting-***
Effects: Loss of profit respectively difference of the gross margins of GM maize and the alternative crop (e. g. non-GM maize) due to - loss of yield - probably increased variable production costs - extra costs due to double ways	Effects: Loss of income due to loss of yield on the discard width - additional work and expenses - labour savings by displacing female parent rows by male parent rows - loss of gross margin - loss of prices because of GM declaration after harvest

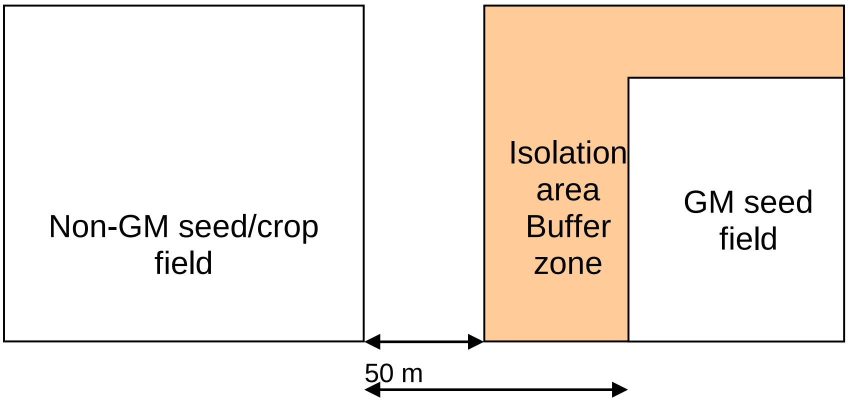
Source: Menrad and Reitmeier (2006) and own statements[2]

S-C. Costs of buffer zones (GM-field)

When using the first option of planting an alternative crop on a surrounding belt on the GM-field (which might be increased from 50 m between fields), the farmer might have to reduce the field size of the GM seed producing field by 100 m in order to achieve the new isolation distance of 150 m as shown in figure 4. On this additional isolation area, the farmer will cultivate the most economic alternative crop taking into account the rules of crop rotation and good farming practice (Menrad and Reitmeier, 2006).

[2] All statements depend on the prices, yields and other economical benefits of the applied alternative crops

Figure 4: Methodology to calculate opportunity costs of planting alternative crop for changing isolation distances in maize seed production



Source: Menrad and Reitmeier (2006) & own entries

The potential impact of increasing the isolation distances in maize seed production and planting another crop on the buffer zone area is shown in table 16. It is assumed that the isolation distance is increased by additional 100 m - thus resulting in a total isolation distance of 150 m – and that the farmer plants another cereal on the increased buffer zone area instead of seed maize (Menrad and Reitmeier, 2006). The reduction of gross margin of planting alternatively wheat or rapeseed is calculated for this purpose - thus representing always a worst case scenario by using the lowest gross margin. Due to the high differences in the gross margins between seed maize and wheat or rapeseed respectively, substantial gross margin losses for the concerned farmers are emerging in this scenario. In case of planting wheat the gross margin losses of this measure amount to 708 €/ha which equals to more than 34 % of the variable production costs of seed maize (assuming a yield of 3.5 t) or 29.5 % of the original gross margin (table 16). If rapeseed is planted instead of wheat on the increased isolation area, the opportunity costs will further increase due to the lower gross margin of rapeseed compared to wheat. With opportunity costs of about 809 €/ha and 33.8 % share of the gross margin the additional isolation distance by a rapeseed crop buffer zone is less economical.

Table 16: Opportunity costs of increasing isolation distance in maize seed production and cultivating alternative crop

Parameter	Specification	
Size of GM seed-producing field	5 ha (224 x 224 m)	
Variable production costs GM seed	2,060 € per ha	
Gross margin GM seed	2,397 € per ha	
Additional isolation distance	100 m	
Reduction of area of GM seed field	2.24 ha	
Remaining area of GM seed field	2.76 ha	
Opportunity costs of increasing isolation distance (for 5 ha GM seed field)		
Alternative crop	**Wheat***	**Rapeseed***
Gross margin seed maize current practice	11,985 €	
Gross margin remaining seed maize (2.76 ha)	6,616 €	
Gross margin alternative crop (2.24 ha)	**1,830 €**	**1,322 €**
Gross margin of adapted practice	8,446 €	7,938 €
Opportunity costs of co-existence measures	3,539 €	4,047 €
Opportunity costs in relation to economic parameters		
Opportunity costs of buffer zone	708 €/ha	809 €/ha
% of variable production costs	34.3 %	39.3 %
% of gross margin	29.5 %	33.8 %
* Gross margin wheat: 817 €/ha; rapeseed 590 € per ha (DLZ, 2007)		

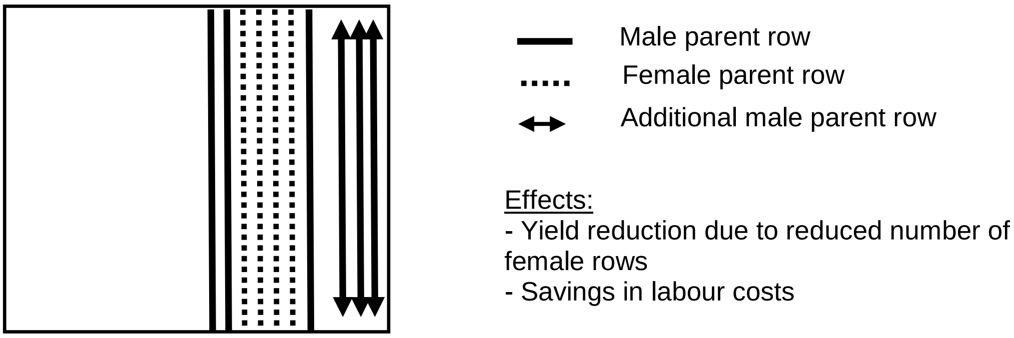
Sources: Calculations of Menrad and Reitmeier (2006), upgraded with figures from DLZ (2007), KTBL (2007)

However, a significant rise in the opportunity costs for farmers can be expected in case the isolation distances in maize seed production are further increased by buffer zones.

S-D. Costs of discard width

Instead of cultivating an alternative crop (like wheat) on an increased isolation area, farmers have the option of planting additional male parent rows around a non-GM seed field which have similar effects in terms of reducing cross pollination between GM and non-GM varieties by rising the non-GM pollen amount in competition to GM pollen. In this case the non-GM seed-producing farmer looses yield in seed production if he replaces (seed-producing) female parent rows by pollen-producing male rows, but additionally he does not have to castrate parts of the female rows, thus resulting in labour cost savings (figure 5). Since the GM farmer who introduces a new GM variety in a region is regarded as being responsible for ensuring co-existence, the non-GM farmer will ask for compensation of his additional costs so that these costs have to be assigned to the GM farmer who will be asked to pay compensation.

Figure 5: Methodology to calculate effects of planting additional male parent rows in maize seed production



Source: Menrad and Reitmeier (2006)

Using the above-described calculation scheme, the opportunity costs of planting additional male rows on a 5 ha squared GM seed-producing field are shown in table 17**.** In case six additional male parent rows are planted on a neighbouring non-GM field (Messéan et al., 2006), this will result in opportunity costs of almost 98 €/ha which equal to 4.8 % of the variable production costs or 4.1 % of the gross margin of seed maize production in Baden-Württemberg (table 14). If 18 male parent rows have to be planted in order to achieve a certain threshold of GM adventitious presence, the opportunity costs of this measure will increase by factor 3 compared to the planting of six additional male parent rows (Menrad and Reitmeier, 2006).

Table 17: Opportunity costs of planting additional male parent rows in maize seed production

Parameter	**Specification**	
Size of GM seed-producing field	5 ha (224 x 224 m)	
Variable production costs	2,060 € per ha	
Gross margin GM seed	2,397 € per ha	
Additional number of male rows	6	18
Savings in labour input for male rows	85 hours/ha	
Opportunity costs of planting extra male rows (for 5 ha non-GM field)		
Gross margin seed maize current practice	8,775 €	8,775 €
Income loss due to reduction of yields	592 €	1,777 €
Labour savings (castration)	98 €	293 €
Total opportunity costs of co-existence measures	494 €	1,484 €
Opportunity costs in relation to economic parameters		
Opportunity costs of additional male rows	98.80 €/ha	296.80 €/ha
% of variable production costs	4.8 %	14.4 %
% of gross margin	4.1 %	12.4 %

Source: Calculations modified according to Menrad and Reitmeier (2006)

S-E. Costs of administration and certification

Around 97 % of all maize seed multiplied on German fields is certified seed. Thus, the costs of certification of non-GM maize seed and GM maize seed are considered as similar in both cases and no higher costs for GM certification are expected. As there exists also no information what kind of records need to be kept at the seed company or at the seed-producing farm with regard to GM production it was impossible to predict how much the annual administration might cost but it cannot be excluded that some costs for education and certification for producing or growing GM crop might appear in future. In this case the costs are regarded as non-recurrent costs so that per hectare costs depend on the actual farm size and also on the timeframe in question. In our analysis the costs are considered to be negligible and not included in the executive cost summary.

S-F. Organisation costs for seed allocation

A special case study was conducted in the framework of the JRC/IPTS co-existence study (Messéan et al., 2006) which analysed the organisational efforts for a company which organises certified maize seed production in Germany on behalf of several seed breeding companies. The analysed company is part of one of the most important Trade and Service Companies in the agricultural sector in Germany.

The company has contracts with seed breeding companies as well as farmers in specific regions in order to organise the propagation of certified maize of a specific variety. The farmers inform the company which fields should be used for this purpose. Based on this information the company forms so-called “isolations” (i.e. specific parts of the region in which a specific maize variety is propagated) which fulfil the national regulatory requirements concerning isolation distances. The company tries to arrange a solution with the farmers in conflict cases in the following ways:

- All possibilities to reduce the required minimum isolation distance have to be checked whether they can be realized in the specific case.
- Cultivation of the non-seed maize variety outside the “isolations” mainly due to exchange of fields with other farmers.
- Propagation of a maize seed variety with differing flowering time.

Altogether, increasing isolation distances will significantly decrease the value added both for the farmers in the region and the service company organising production of certified maize seed.

In addition to the described consequences on the production and market side, there are additional time requirements and management costs for re-organising the seed producing area in a region due to increased isolation distances. Messéan et al (2006) stated, that there are hardly any data publicly available which analyse the time requirements and management costs of organising seed producing fields in a region. Messéan et al (2006) estimated in their case study on maize seed production in Germany that around five minutes per hectare are required for the organisation and management of the seed producing area in the region. However, the company was not able to quantify the additional time requirements resulting from a potential increase of the isolation distance required for maize seed production. Nevertheless, there is an agreement among all interviewed experts that the fixed costs of certified seed production will increase both for seed breeding and multiplying companies as well as for farmers co-operating with them. These higher fixed costs will result in increased total production costs and declining profit margins of seed-producing farmers and seed breeders if only part of the additional costs can be transferred to fodder or grain maize producing farmers.

Another indirect impact of this co-existence measure refers to additional conflicts among seed producing farmers. In principle there are two strategies of seed multiplying companies to re-organise the seed production area in a region:

- Significant reduction of the number of farmers who multiply maize seed and constant cultivation area per farmer

- Constant number of farmers who produce maize seed and a significant decrease of the average seed multiplying area per farmer

It can be summarized that in the case of co-existence of GM seed production and non-GM maize crop/seed growing in a region, allocation efforts and costs will appear. Due to many influencing variables (e. g. spatial and climate conditions, field and farm structures, isolation regulations and possibilities) it is hardly feasible to quantify the costs in a representative figure. Otherwise, some cost types, determined and imputable as ‘allocation costs’ in other studies (Messéan et al., 2006; Bock et al., 2002), like incidental isolation costs are already considered in the previous cost types. Therefore, for the calculation of this report no special allocation costs are imposed on the seed company.

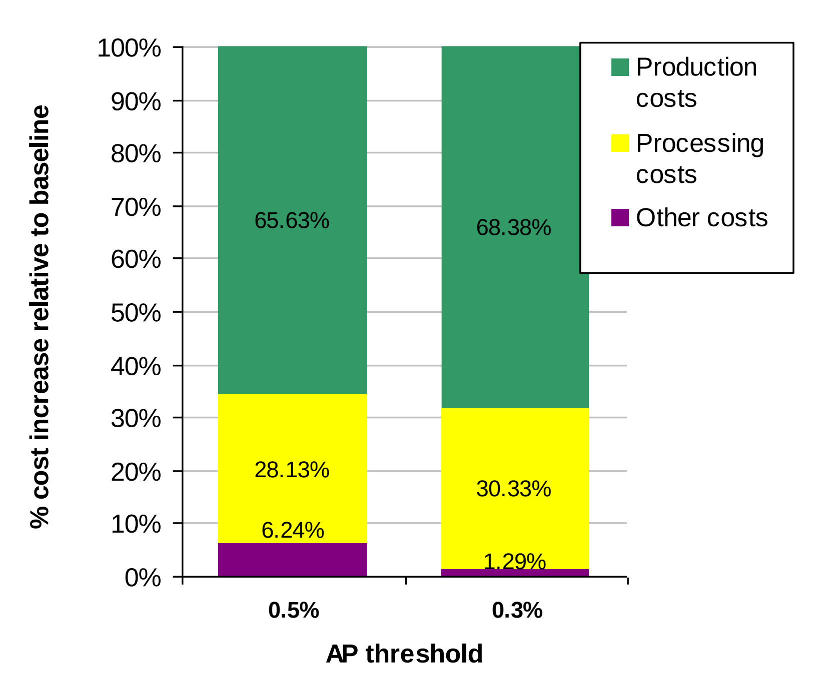
S-G. Miscellaneous costs: seed processing costs

Processing and other costs: the previous cost types S-A. to S-E. represent costs which can occur at the critical points on-field or on the farm-site. Cost type S-F. considers costs that emerge when the seed company has to execute measures to institute and distribute GM seed to contracted seed farmers in a maize growing region without violating co-existence regulations.

To imply costs that can appear at the “seed company site” results from Magnier and Kalaitzandonakes (2007) and Kalaitzandonakes (2008) are adducted, who have investigated the economic effects of co-existence on the European maize seed industry (German and French Seed Companies) by empirical surveys of several seed producing companies. Kalaitzandonakes (2008) tried to identify costs of compliance of certain regulated adventitious presence (AP) thresholds of GM crop in maize growing regions by taking the seed companies and cooperating seed farms as one “seed producing/processing” unit. Certainly, they point out the producing and processing of AP varieties as cost driver and simulated the implementation of these varieties in a region with 20 % GM-adoption.

Kalaitzandonakes (2008) distinguishes the occurring costs in processing costs, producing costs and other costs. The producing side contains cost types as land costs, material input costs, laboratory and field management costs and costs that result from measures maintaining isolation distances, but also field costs like extra land costs, block planting etc. The processing costs include costs that occur in the facility of the seed company during drying and conditioning. Further costs might occur by changes in managerial practice and inefficient utilisation of equipment and machinery. “Other costs” represent testing costs and expenditures for extra storage facilities. Kalaitzandonakes (2008) computes the distribution of incremental costs by AP thresholds of 0.3 % and 0.5 % and relate these increased compliance costs to the baseline of seed production efforts (normal operations) (figure 6).

Figure 6: Structure of adventitious presence compliance costs in seed maize



Sources: Kalaitzandonakes (2008), Magnier and Kalaitzandonakes (2007)

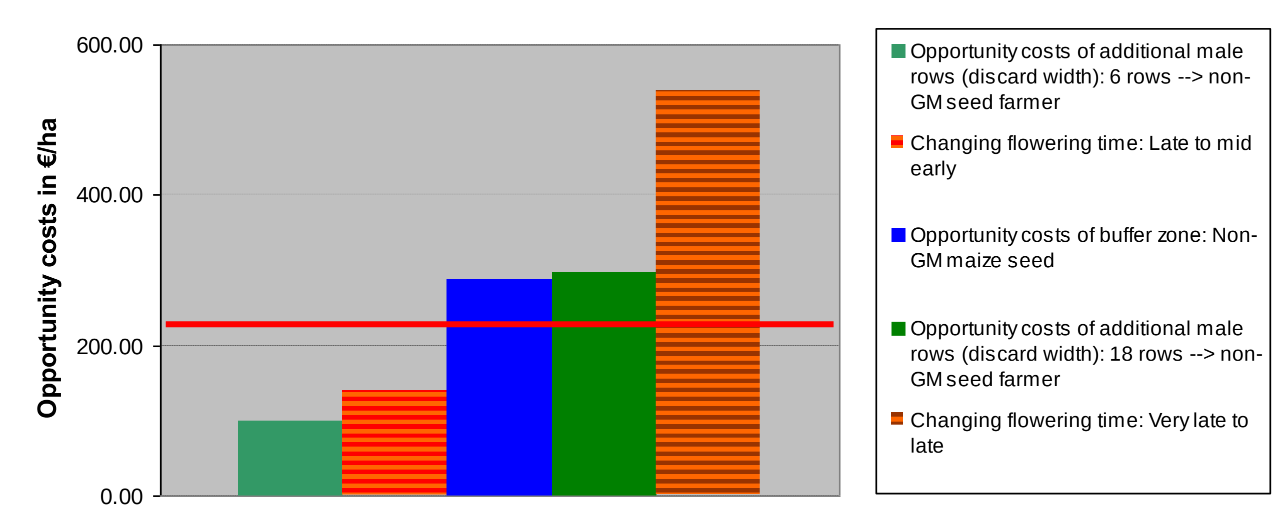
Kalaitzandonakes (2008) stated average compliance costs on the seed level of 32 % for the 0.5 % AP threshold and 40 % for the 0.3 % threshold as results of his empirical estimates, which are quite high compared to the results of our calculations. This higher dimension is caused by considering added production costs for different co-existence measures.

Figure 5 reveals that the percentage of processing costs (including monitoring and extra storage facilities) can be indicated with around 1/3 of the total additional costs (0.5 % threshold). These additional processing costs are not respected in the following cost summary as they cannot be implied directly on the appearance of costs of maize seed production due to co-existence and are more influenced by seed companies' existing assortment- and quality management.

Executive summary

The results of the previous co-existence cost calculations by separating GM seed from non-GM environment (opportunity costs) differ strongly depending on the measure applied. Assuming a squared maize field of 5 ha and considering the different measures like planting maize varieties with differing flowering times, introducing a buffer zone and planting an alternative crop or planting additional male rows, the range of the occurring prevention costs last from about 100 € up to around 1,000 € per ha (figure 6). The parameters of the different strategies are specified in the previous paragraphs. The decision of the application of a specific measure strongly depends on factors like field size, GM adoption in the region, responsibilities of the farmer or compulsory isolation distances and specific regulations of the seed breeding companies. It seems that the non-GM seed farmer strategy of planting additional male rows on the discard width is the most economical way to achieve a compulsory isolation distance. But it could be emphasized that a 6 - or even an 18 - male row cannot accomplish a required threshold with special climatic and spatial conditions. Thus, an increased number of extra male rows with lower gross margin might increase the opportunity costs drastically. The opportunity costs resulting from increased isolation distances or buffer zones strongly depend on the gross margin of the cultivated alternative crop. In order to consider realistic economical decisions of a farmer who disposes this prevention strategy, wheat (gross margin: 817 € per ha) is taken into account as it has a comparable high gross margin as the GM maize seed (2,397 € per ha) in comparison to the quite low gross margins of other alternative crops (e. g. rapeseed) (see figure 7).

Figure 7: Opportunity costs of different isolation measures and parameter (5 ha field size)



However, to get a realistic result for isolation within co-existence an average of the seven demonstrated reference results is respected for the executive summary of all relevant cost types in the seed level (red line: 214.00 €/ha**)** (table 18).

Table 18: Total opportunity costs of non-GM maize seed production in a 50 %-adopted GM maize region

Seed producer - S	*Costs per unit*	*Unit*	*Percentage*
A. Cleaning/Flushing costs	11.00	€/ha	*5.2 %*
B. Costs of time isolation			
C. Costs of discard width (Non-GMO)	214.00	€/ha	*94.8 %*
D. Costs of buffer zones (GMO)			
E. Costs of administration/certification	---	€/ha	---
F. Organisation costs for seed allocation	---	€/ha	---
G. Miscellaneous costs: seed processing	---	€/ha	---
Total prevention costs	**225.00**	**€/ha**	*100,0 %*
Total additional prevention costs per seed unit (considered yield: 3.5 t/ha)	**64.28**	**€/t**	
Price loading (basis: conventional produced maize) seed with 950 € per ton)	**6.8**	**%**	

The final result of the aggregation of the three activated cost types – cleaning machinery, additional processing & monitoring and isolation strategy – shows that with prevention costs of 225 € per ha or 64.28 € per ton non-GM maize seed a total of 6.8 % has to be added on the current price of 950 € per ton produced seed. By taking into account that with additional costs of administration, seed allocation, seed processing or lower variable costs in GM seed production – which all are not taken into account for this calculation – the total prevention costs might be even higher. So, the foregoing stated figures of additional technology fees by Brookes (2002) and Reitmeier et al. (2006) might be clearly reduced because of increased costs of co-existence and traceability systems.

Farm level

The critical points of maize production at farm level are a potential admixture of GM and non-GM material during sowing, harvest and transport as well as cross pollination due to pollen flow. Four different additional measures can be suggested in order to reduce cross pollination (figure 7). Due to a variety of influencing factors (like e.g. penetration rate of GM crops in a region, field sizes and structure, positioning of the fields, wind direction, maize varieties grown in a region) it is very complicated to examine the economic impact of all suggested co-existence measures not least that so far as there are only few studies and figures for sensible calculations available. Thus, it is not feasible to get an overall picture of the economic effects of co-existence for maize growing on the farming level.

An adequate spatial isolation distance between GM and non-GM fields is an important measure to secure co-existence without hybridisation [5]. Although maize pollen does not spread over high distances, there is low knowledge of sufficient isolation distances and an unfinished political skirmish about justified regulations to assure the 0.9%- thresholds. In 2007, the German ministry of agriculture proposes in a regulation of good farming practice a minimum distance of 150 m to a conventional maize field and 300 m when organic maize is grown on the neighbouring field (BMELV, 2009). Menrad and Reitmeier (2008) conducted cost calculations for applying buffer zones as co-existence strategy. These costs – depending on the regional conditions and compliance of certain regulations – are taken to identify the share of discard widths costs. In order to avoid admixture, farmers have to clean the respective machinery (seeding machine, combine, trailer or truck) - thereby taking into account whether the farmer owns these machines or whether he shares them with other farmers who could possibly produce GM maize. This kind of machinery sharing is generally organised by special companies. In the latter case opportunity costs for not using the machinery during the cleaning process have to be taken into account when calculating cleaning costs (table 15). Other incurred costs like the difference in gross margin and on-field monitoring costs are also accounted for maintaining the total costs in case of co-existence between GM and non-GM maize production on farm level in Germany.

F-A. Gross margin

In the following, several existing data sources are combined to get realistic results for German maize crop growing regions. The schedule of variable costs composed by Menrad and Reitmeier (2006) for a growing region in the South-west of Germany is taken to detect variable costs and gross margin. Due to the currently marginal growing situation of GM-maize in Germany, it is very difficult to get realistic data of price losses and yield increases of Bt-maize. Therefore, figures proposed by Degenhardt et al. (2003) are used to round off data for calculation. They conducted a profitability calculation for different measures of corn borer combat, including using conventional insecticides, biological treatment and Bt-maize cultivation. Degenhardt et al. (2003) assumed an income of around 100 € per ton conventional maize, special insecticide applications for corn borer treatment of 40 € per ha and a price premium of Bt-maize seed of 35 € per ha. They also stated a higher yield of Bt-maize for the two growing regions of Rheintal (1998-2000) and Oderbruch (2000-2002) of 12.5 % and 13.1 %.

Because of the different published yield and price premium statements of different regions and studies the yield extension of Bt-maize is constituted with 10 % for the further calculations and the price premium of non-GM maize is assumed with around 5 %. Real prices and yields for non-GM maize are fixed by referred data from KTBL (2007). The estimated gross margin of a potential growing of Bt-maize in Germany is shown in table 19.

Table 19: Economics of conventional (non-GM) maize and Bt-maize

Parameter		**Non-GM maize**	**Bt-maize**
Yield	t/ha	9.5	10.5
Price	€/t	100	95
Total income	**€/ha**	**950**	**998**
Costs of seed	€/ha	170	205
Plant protection	€/ha	62	22
Harvest	€/ha	105	105
Irrigation 1000m³	€/ha	220	220
Fertilizer	€/ha	120	120
Hail insurance	€/ha	10	10
Variable costs	**€/ha**	**687**	**682**
Gross margin I	**€/ha**	**263**	**316**
Compensation payments	€/ha	480	480
Gross margin II	**€/ha**	**743**	**796**
Differences in economic parameters between conventional and Bt-maize			
Difference in prices	€/t	-5	
Higher yields	%	+10	
Higher seed costs due to technology fee	€/ha	+35 €	
Savings in plant protection due to insect resistance of Bt-maize	€/ha	-40	
Economic benefit of Bt-maize (gross margin benefit)	**€/ha**	**+53**	

Sources: Menrad and Reitmeier (2006), upgraded with data from Degenhardt at al. (2003) and Menrad and Reitmeier (2008)

Regarding the statements of Degenhardt et al. (2003), the additional seed costs for Bt-maize increase with 35 €/ha (an exaltation of around 20.5 % compared to the non-GM variety). These higher costs are confronted with the benefit of a reduced pest management of 40 € as saving in pesticides. Altogether, these considerations result in a potential gross margin of Bt-maize of 796 €/ha which is 53 €/ha or 7.1 % higher than the corresponding figure of the non-GM crop maize variety.

F-B. Cleaning the machinery

The costs of cleaning machinery in maize crop production are shown in table 20. Due to opportunity costs of renting machinery, the cleaning costs of shared machinery outreach by far those of own equipment of the farmer (table 20).[3] For further calculations, the cleaning costs of 11.51 €/ha for own machinery are used.

[3] Opportunity costs for the rented machinery occur due to the fact that farmers have to pay a renting fee for the machinery which is higher in case the machinery has to be cleaned after e. g. seeding or harvesting.

Table 20: Costs of cleaning machinery in maize crop production

Measures crop production	Assumed cleaning operations (15 ha field size)	Own machinery	Shared and rented machinery*)
		€/cleaning	
Clean single seed drilling machine	1	7.61	38.38
Clean combine	1	3.81	56.84
Clean trailer	10	0.63	1.48
Total costs**) **Costs per ha**		157.72 € **10.51 €/ha**	250.02 € **16.67 €/ha**

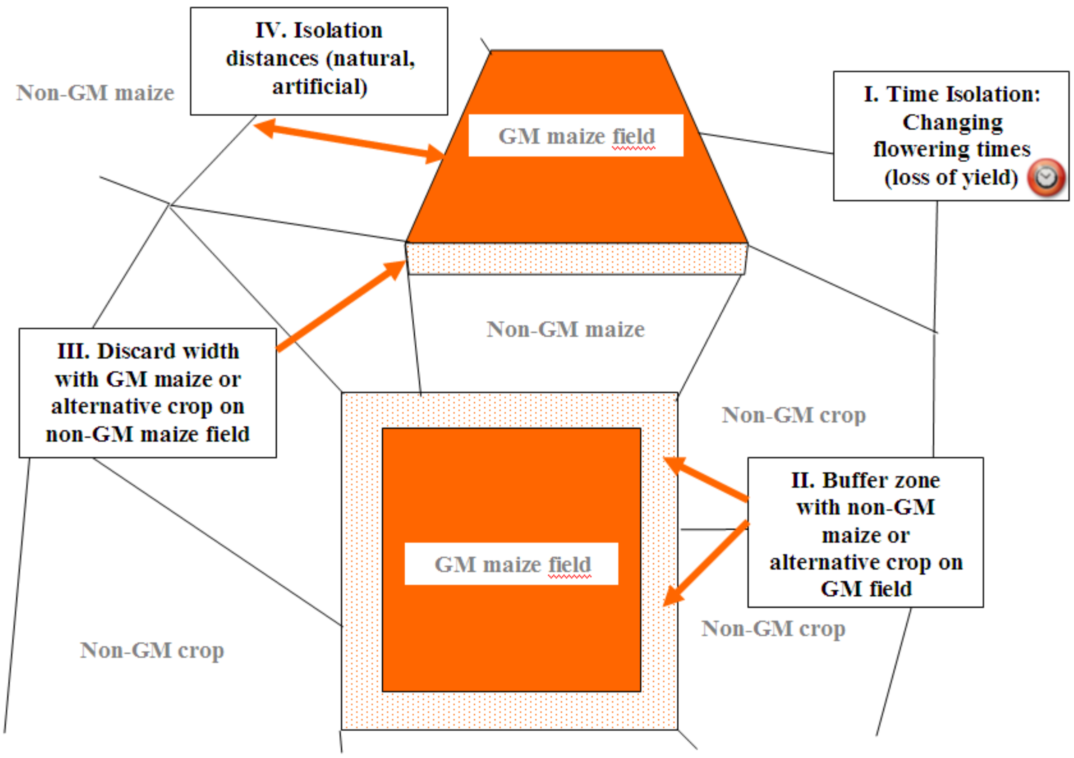
*) Renting fees for collectively used machinery were used for calculating the costs of shared machinery.
**) Respected relevant labour costs and cleaning durations

Source: Menrad and Reitmeier (2006)

Isolation measures (F-C. - F-E.)

The possibilities of implementing distance regulations between GM and non-GM maize varieties are shown in figure 8. Each of them has different economic impacts and corresponding costs depending on several influencing factors.

Figure 8: Possible field isolation measures



- **I. Time isolation:** Difference in flowering time of maize varieties might result in yield losses → *if losses occur for later sown GM varieties direct costs for GM farmer*
- **II. Non-GM buffer zones around the GM field - extra sowing:** GM farmer has to sow a non-GM buffer around his GM field. The additional costs result from differences in the

gross margins between GM and non-GM maize (or alternative crop), additional efforts for land use management as well as extra machinery costs → *direct costs for GM farmer*

- **III. Discard width on the non-GM field - extra harvest:** the non-GM farmer does not harvest those parts of the field which is closely located to a neighbouring GM maize field. The GM farmer pays the non-GM farmer the price of non-GM maize (the GM farmer only has additional costs if the non-GM price is higher than the GM price) → *compensation payments*
- **IV. Isolation distances:** Adequate distances between GM and non-GM fields, normally given in the regional structure; for German regulations a distance of 150 meters is constituted to prevent cross-pollination of maize. As many factors influence the situation (GM adoption rate, field sizes, infrastructure and field allocation, etc.) it is not possible to calculate co-existence cost in general for this measure.

It is obvious that the implementation of a specific isolation measure between GM and non-GM maize fields depends on many variables (field size, GM adoption rate in region, alternative crop, production preconditions, national or EU governmental regulations and thresholds etc.) that have to be balanced in economical and ecological reasons. Several studies cover definition and calculation of costs due to isolation measures (Bullock et al., 2002; Bock et al., 2002; Menrad and Reitmeier, 2006; Gómez-Barbero and Rodruigez-Cerezo, 2007). For the further cost line-up we use the results of Menrad and Reitmeier (2008) who emphasize costs of using buffer zones around Bt-maize by varying GM adoption rate (10 %, 30 %, 50 %) for different considered isolation distances (20 m, 100 m) for two model regions (intensive and extensive maize production) in southern Germany (tables 21 and 22).

Table 21: Additional costs of buffer zones on Bt-maize fields in an intensive production region

Model region I – intensive maize production (with high proportion of maize in crop rotation) *Total maize area: 9,101 ha* *Number of fields: 4,224* *Number of farms: 869* *Gross margin for Bt maize is 66 €/ha higher than for conventional varieties*							
Adoption rate	Bt maize area (ha)	Number of Bt fields	Number of Bt farms	Affected convent-ional maize area (%)	Buffer zone area	Bt-maize farms in region (total add. costs)	Accu-mulated additional costs €/ha
Isolation distance of 20 m							
10%	851	394	87	1	292	19,289	22.7
30%	2,420	1,211	261	3	722	47,680	19.7
50%	3,921	1,755	435	4	1,154	76,134	19.4
Isolation distances of 100 m							
10%	851	394	87	7	634	41,868	49.2
30%	2,420	1,211	261	20	1,575	103,930	42.9
50%	3,921	1,755	435	31	2,364	156,053	**39.8**

Source: Menrad and Reitmeier 2008 (basic data from Degenhardt et al., 2003)

Table 22: Additional costs of buffer zones on Bt-maize fields in an extensive production region

Model region II – extensive maize production (with low proportion of maize in crop rotation) *Total maize area: 6,105 ha* *Number of fields: 3,083* *Number of farms: 936* *Gross margin for Bt maize is 38 €/ha higher than for conventional varieties*							
Adoption rate	Bt-maize area (ha)	Number of Bt fields	Number of Bt farms	Affected conventional maize area (%)	Buffer zone area	Bt-maize farms in region (total add. costs)	Accumulated additional costs €/ha
Isolation distance of 20 m							
10%	530	279	94	1	118	4,499	8.5
30%	1,557	781	281	1	256	9,741	6.3
50%	2,427	1,161	468	3	411	15,625	6.4
Isolation distances of 100 m							
10%	530	279	94	5	320	12,178	23.0
30%	1,557	781	281	11	755	28,695	18.4
50%	2,427	1,161	468	19	1,219	46,306	**19.1**

Source: Menrad and Reitmeier 2008 (basic data from Degenhardt et al., 2003)

Taking a look at the accumulated additional costs per ha, it is remarkable that the costs related to the total area are decreasing by increased adoption rates. This can be explained by the fact that in regions with lower affected conventional maize areas the number and pressure of contaminations of neighbouring fields is lower and the costs are distributed on more field units of the total considered area. Although the currently compulsory distance between GM and non-GM fields in Germany is 150 m laid down in state regulations, the calculated costs for buffer zone widths of 100 m can also be seen as eligible in case an existing 50 m space between GM and non-GM fields has to be extended by this isolation measure. For the total isolation costs for our farm level calculation the average between the two considered regions with a GM adoption rate of 50 % and the applied buffer zone width of 100 m is taken. Therefore, co-existence costs due to buffer zones are fixed with 29.45 € per ha. Here again, these costs will be imposed on the GM farmer, but for our cost calculation they run in the compilation of all occurring costs of co-existence and traceability.

F-F. Monitoring costs

It is difficult to create a representative scenario for on-field and storage monitoring as the scale of testing depends on many factors like field sizes, fields GM-periphery, wind direction, out-crossing potential of the cultivated plants or farmers' production strategies. To ease the cost calculations, the study about evaluation of co-existence costs of agricultural crops of Bock et al. (2002) is taken into account which compares data of different farm types (conventional-intensive production up to organic farming) in different GM penetration scenarios to elevate differences in cost structure of farming practices in the background of co-existence. Monitoring costs for conventional and organic grain maize production are meant to be composed by planning, implementation, on-line monitoring, sampling, GMO analysis, review and external audits. Database of the study were information of model farm types in French regions. Therefore, the total costs should be considered carefully for other European regions and might be adapted in the background of different general conditions (legislation, practice and application methods). Because of this, the results of the study of Bock et al. (2002) cannot be transferred exactly to this study, only the dimension of the results should be assumed. Table 23 shows the total monitoring costs for 3 model farms. The intensity of testing strongly affects the costs.

Table 23: Monitoring costs of grain maize production in France

Maize	Farm 1 Conventional, intensive production		Farm 2 Organic production		Farm 3 Conventional, non-intensive production	
Crop area (ha)	50		6 (18)*		20	
Field size (ha)	3.5		3.5		20	
Yield (tonne/ha)	10.15		9.0		10.06	
Monitoring system	intermediate		rigorous		intermediate	
GMO analysis frequency (no./field & year)	0.5		0.5		0.5	
	€/ha	€/tonne	€/ha	€/tonne	€/ha	€/tonne
Planning	7.8	0.8	21.5	2.4	19.4	1.9
Implementation	1.2	0.1	3.2	0.4	2.9	0.3
On-line monitoring	0.2	0 (0.02)	13.3	1.5	0.5	0.1
Sampling	2.5	0.2	2.2	0.2	2.4	0.2
GMO Analysis	25.7	2.5	25.7	2.9	4.5	0.5
Review	4.0	0.4	11.1	1.2	10.0	1.0
External audit	4.9	0.5	13.6	1.5	12.3	1.2
Total costs	**46.2**	**4.5**	**90.8**	**10.1**	**52.0**	**5.2**

* It is assumed that three farms co-coperate and share the costs, which are fixed on farm level.

Source: Bock et al. (2002)

Bock et al. (2002) also assume a 50 % GM adoption rate in the considered regions in France, but presume other conditions for their model farm companies, as crop area, field sizes, yields (gross margin) and the grade of liability of monitoring intensity are concerned. For our calculations the total costs are estimated to around 2/3 of the cost level of the conventional farm types 1 and 3 in the study of Bock et al (2002). Costs for review and external audits are omitted because of the lack of comparableness of certification and audits practice in the different countries and the costs of planning, implementation and on-line monitoring are conspicuously reduced because of the habitual application of sampling and analysis of the GMO-farmer. A second reason for the non-consideration of these single costs is the strong dependence on crop area of each farm company. The total costs of monitoring for this study are defined with 30 € per ha or 3.1 € per ton.

ZGR (2004) stated monitoring costs up to the elevator level with around 3.5 € per ton (containing sampling, GMO analysis and traceability measures for seed and crops up to the elevator level), thus the dimension of the assumed cost figure is quite eligible.

F-G. Depreciation for additional storage, drying and infrastructure caused of parallel production

In the case of parallel farming practice – GM maize and non-GM maize – separated storage capacities and drying components have to be installed. KTBL (2007) indicate investment and maintenance costs of around 10 to 30 € per ton and year, depending on crop amount and operating grade. For our calculating of co-existence costs on farm level it is assumed that one farmer grows either only non-GM or GM maize. So the risk of mixture of GM and non-GM commodity does not occur after harvesting on a farm. Thus the strategy of delivering the maize to the next level (elevator) does not imply additional storage and infrastructure capacities for segregation for the single farmer.

F-H. Possible additional transport costs to the next level (cleaning)
Here again it is provided that the farmers cultivate either solely non-GM or GM maize. So the risk of admixture of GM and non-GM commodity does not occur after harvesting on the farm. Supplying the elevator is done with own trucks and in case several farmers share transport vehicles, the cleaning of the trucks and trailers has to be done anyway and cannot be declared as pure GM-prevention cost type.

F-J. Costs of administration/certification
No extra costs are appointed for administration and certification.

F-G. Miscellaneous costs
No further costs considered.

Executive summary
In aggregation of the presumed four incurred cost types, the additional production costs (decreased gross margin of conventional GM-maize), cleaning and flushing costs, isolation efforts (buffer zones) and on-field monitoring, the total result is stated with 122.96 € per ha or 12.94 € per ton by defining a yield of 9.5 tons per ha (see table 24). The price loading describes on the one hand the incurred costs for producing non-GM maize in a 50 % GM adopted region, and on the other hand this figure can be transferred to the next chain level and can be used as extra charge of the costs for maize as raw material at the elevator level.

Table 24: Total prevention costs of non-GM maize farming in a 50 %-adopted GM maize region

Farming level - F			
A. Additional production costs Non-GMO	53.00	€/ha	*42.8 %*
B. Cleaning/Flushing costs	10.51	€/ha	*8.4 %*
C. Costs of time isolation	---	€/ha	---
D. Costs of discard width (Non-GMO)		€/ha	
E. Costs of buffer zones (GMO)	29.45	€/ha	*24.2 %*
F. Monitoring costs	30.00	€/ha	*24.6 %*
G. Depreciation for additional storage	---	€/ha	---
H. Possible additional transport costs	---	€/ha	---
J. Costs of administration/certification	---	€/ha	---
K. Miscellaneous costs	---	€/ha	---
Total prevention costs	**122.96**	**€/ha**	***100.0 %***
Total additional prevention costs per unit	**12.9**	**€/t**	
Price loading (basis: conventional produced maize with 100 € per ton)	**12.9**	**%**	

Maize elevator

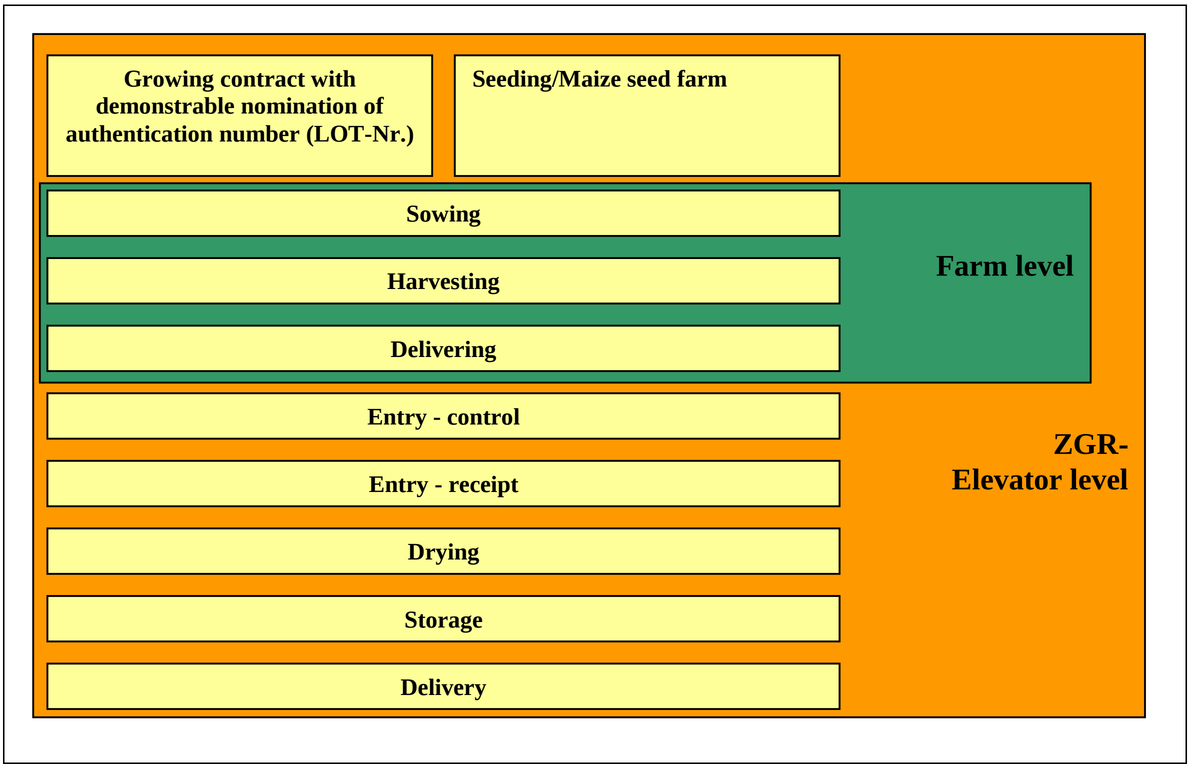
Information and cost calculations in this chapter base on a statement from 2004 of the Raiffeisen-Zentralgenossenschaft (ZGR), a co-operation for elevating and trading agricultural products, operating all over Germany. This hearing demonstrated the approaches and attitudes of the company towards GMO and their current measures and proceedings with co-existence and traceability in the crop lines (ZGR, 2004).

General assumptions and state of the art of ZG Raiffeisen

The co-operation includes producers' organisations, several seed conditioning farms, crop farmers and elevating centres to organise and monitor the growing and elevation of agricultural crops. Consulting and special elevation services afford a market-driven alignment of agricultural production, price validations and real-time harvest coverage. The ZGR collaborates with several crushing and processing companies for agricultural products (mills, malt houses, starch and forage industry) and creates 70 % of the whole turnover of grain and forage maize in Germany. All storage and production sites of the ZGR are certified by ISO 9001:2000 and HACCP and by QS-standard in forage production. To fulfil the demand of their partners and customers no genetically modified corn, maize and oilseed products are elevated. The company claims complete traceability of maize and wheat and promises reliability and transparency for clients and customers.

Regarding the maize line of the ZGR, an overview of the responsibility and "production" steps of the elevator is shown in figure 9. The elevator organises the seed allocation and the delivering procedure of the farmers' harvest. The drying at the elevator's storage sites depends on the arrangement with the single farmer and the natural condition of the delivered maize charges.

Figure 9: Maize processing chain at the elevator level



Source: Own illustration based on information of ZRG (2004)

Up to now the concept of the ZGR of maize production conduce to safe-guarding of non-GM maize especially for mills, starch industry and pet food processors as acceptor. Although GM content is no criterion of selection in the choice of commodities for the feed industry so far, management, practicability, risks and costs are meaningful issues in materials handling at the maize elevator level (ZGR, 2004). For the last decade, ZGR declares a strict non-GM policy due to requirements of their industrial customers. The indemnification of non-GM commodities is carried out by regulation of varieties, educational advertising of farmers and employees, systems of traceability and monitoring. The company estimates the costs of these measures up to 3 € per ton maize (ZGR, 2004). To assure the compliance with compulsory thresholds of GMOs in the delivered and provided maize, contracts for appointed threshold values are signed both with the farmers (labelling liability for 0.5 % respectively 0.9 % threshold) and the customers (ranged from 0.01 % up to 0.1 %). A summary of critical points of admixture that concern the responsibility of the elevator is shown in table 25.

Table 25: Possible critical points of admixture

Farming	Elevation
▪ Seed impurity ▪ Seed and pollen dispersal ▪ Growing and handling of crops ▪ Transportation	▪ Transportation ▪ Entry ▪ Storage ▪ Processing/Commission

Source: ZGR (2004)

ZGR (2004) noted that a contamination of bigger non-GM batches (up to 50,000 tons) with GMO can cause costs of 150,000 € up to 7.5 million € in the price structure in 2004. Additionally the disadvantage in company's image and consumer trust might be even higher and immeasurably. ZGR (2004) also mentioned that in the current situation the monetary disprofit cannot be transferred on the farmer even when he might be the initiator of admixture.

In the current situation, the elevator refers to some obstacles to ensure segregation of GM and non-GM maize field of responsibility. Firstly, the compulsory specifications do not approve GM quick tests at the entry stage for legitimate evidence. Qualitative or quantitative PCR tests have to be conducted. This effects that a real-time monitoring for the input commodities cannot be carried into execution. Secondly, no sampling or restoring samples are gathered by the input of maize. Another negative aspect is that as yet no certain threshold value for maize seed is required. In order to confront these threats the ZGR implies the following approaches for the future:

- Testing of all seed abstraction units
- Investments in preparation of sampling systems at the entry
- Testing of delivering batches
- Increasing costs for self-guarding of non-GM maize
- General segregation on-site

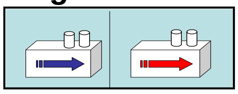
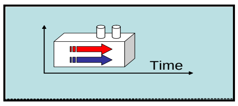
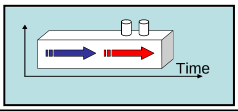
In the following the possible co-existence strategies for elevating or processing companies are defined:

General co-existence strategies (for elevating/processing)

The decision for a certain processing strategy strongly depends on the existing conditions of the companies for segregation and traceability. It is crucial if there are already more sites for an easy segregation or an advantageous infrastructure for registration, processing and storage in order to decrease investment costs for adjusting elevators' activities in the case of co-existence.

The three possible basic strategies for a maize elevating company in order to realise co-existence between GM and non-GM crops are shown in table 26.

Table 26: Possible co-existence strategies at the elevator and processing levels

Strategy	Explanation	Assessment of the strategy
1 Local segregation 	The two types of production are separated in two different factories/association with a competitor	**First best option, under use of existing plants** avoid unintended GMO-admixture during registration and storage activities additional logistical costs due to higher distances to the next GM or non-GM plant respectively
2 Spatial specialization 	Lines are dedicated to one type of products in one plant A-Partial: equipment non-dedicated B-Total: equipment dedicated	**Most expensive** new registration facilities, new transport facilities and new storage facilities must be built requires permanent GMO-testing to avoid unintended GMO-admixture requires higher personnel costs feasibility depends on testing prospects
3 Temporal specialization 	Lines are dedicated to one type of products A: stop and cleaning B: cleaning with products (flushing)	**Technical equipment is essential** new registration facilities, new transport facilities and new storage facilities must be built

1. The strategy of "local segregation" will be the preferred co-existence strategy. This strategy is only feasible if existing plants can be defined into GM and non-GM plants. The construction of a new plant would be too expensive. This strategy will provide proper segregation of GMOs and avoid unintended GMO admixture during registration and storage activities. Additional costs of this co-existence strategy will be increased logistical costs due to higher transportation distances to the next GM or non-GM plant respectively.

2. The "spatial specialization" is the most cost intensive co-existence strategy. In this case new registration facilities, new transport facilities and new storage facilities must be built. This option would require permanent GMO testing to avoid unintended GMO admixture during registration and storage action mainly deriving from human errors. However, the time period which is available to realize the GMO testing is only between 10-15 minutes and thus too short to get a result in time with the legally valid GMO tests which are available on the market (i.e. PCR tests). It also requires higher personnel costs mainly resulting in measures which are necessary to avoid unintended GMO admixture like e. g. sampling, cleaning, controlling. Taken all together, this concept is not realistic unless a GMO rapid-test for maize will be available.

3. The "temporal specialization" might be feasible for certain products if the product flow is straight forward without any loops or floating tanks and no development of dust (closed processes) and if there are no spots where procrastinations are possible over longer time frames. Additional costs could be evoked throughout investing in new storage facilities as storage is a

very critical point considering the risk of unintended GMO admixture. The available storage facilities are decisive if proper separation of GM and non-GM commodities would be possible. This option involves the highest risk of unintended GMO admixture and thus will require high efforts and costs throughout GMO analytics.

ZGR (2004) stated in their hearing of the application about their co-existence policy in 2004 that the registration by two lines in one factory is not possible due to missing capacities. High investment costs for a second drying system at one site prohibits an applying of the two parallel running strategies, the temporal and the spatial specialization.

So, only the strategy of local segregation remains to assure separation of GM and non-GM maize in the elevator division. Anyhow, ZGR still sees problems in the critical points of segregation as the pollen dispersal, entry controls, sampling and increased costs of storage and internal transportation. To achieve a strict regional segregation of GM and non-GM maize separated downstream markets for both have to be existent. Therefore, the regarded elevator company decides to stay in a non-GM line for maize for food production and mixture commodity for the feed industry.

In this context ZGR (2004) estimated hypothetical price relations of GMO maize of around 120 % and non-GM maize of 140 % based to 100 % of mixture commodity. The price difference between non-GM maize and GM maize is therefore around 17 % relating to the estimations of the ZGR and both implicate higher prices than the mixture commodity without active segregation.

To that effect, an introducing of co-existence would have a price benefit in the initial phase. But co-existence also brings high admixture potential before or whilst harvesting and is currently not free of threats (image, liability). Co-existence necessitates strictly separated entries and specific know-how at the commodity receipt and commercialisation. In a long term, multifaceted admixture threats and high segregation costs have to be kept in mind. Furthermore, the question arises if the demand side honours the efforts of segregation and traceability. Which thresholds of GMOs in non-GM products are demanded and how can they be assured? ZGR stated that, both short-term and long-term, co-existence of the different crop growing types is doubtful due to high costs of securing. The ZGR has a high self-interest in ensuring co-existence and requests clear regulations of thresholds for seed and growing crops. Seed testing, crop testing and systems of traceability are the measures to ensure non-GM maize production.

In the following, the estimated costs to fulfil the required co-existence measures – expected by the ZGR (2004) – in combination with results of the conducted interviews and transferred data from other analysed supply chains are used to identify relevant cost types and to calculate the efforts for the elevator industry in the case of co-existence in the maize supply chain in Germany.

Cost calculations maize elevator

In this chapter the cost calculations for a reference elevator company are presented, implying local segregation as co-existence strategy (see table 22). As the Raiffeisen- company has several storage and transition sites for agricultural crops, this strategy may be the best decision in economical and realisable sense. Table 27 shows all the assumed conditions (share GM commodity, capacities, product price and co-existence & traceability measures). Cost types like additional storage, cleaning and flushing would occur when applying other strategies (compare previous chapter).

Table 27: Set-up for the cost calculation at the elevator level applying local segregation

Elevator (Entry, Cleaning, Storage)	
Reference	ZGR eG
Produced product(s)	Maize for starch production (Included: gathering, drying, commission)
Capacity	Total 250,000 tons
Share GM commodity	**50 % (high regional adoption rate)**
Commodity import	Not assumed
Separation method of processing chain	
- Local separation	**Yes (best option using existing separated facilities)**
- Spatial separation	**No**
- Time separation	**No**
Input testing	Yes
Output testing	Yes
Additional transport costs	Assumed for a 50% regional GM adoption rate
Additional storage	No
Cleaning repositories	
- Cleaning	No
- Flushing	No
- Production line stop	No
Extra efforts for growing supervision	(Yes)
Extra seed certification costs	No
Price of product (GM-standard)	205.00 € per ton purified maize (Matif- notation April 2008)

Sources: ZGR (2004) and conducted interviews in 2006

E-A. Commodity, certification and extra transport costs

It is obvious that the commodity and transport costs will increase by an increased regional GM adoption rate as costs for extra prevention measures in the previous levels of the chain load on the commodity price. Additionally, the radius of maize supply from the surrounding farms will also increase when storage sites are getting specialized on GM or non-GM entry and consequently the concentration of registration places for maize will decrease. ZGR (2004) estimates higher costs for transport and storage within the strategy of local segregation of about 10-20 € per ton for their entry capacities. As it is not apparent, which GM adoption rates, transport distances or concentration rate of sites, ZGR (2004) has taken as baseline for their cost calculations, thus the mean of 15 € per ton is used to quantify the additional transport and commodity costs in our cost calculations.

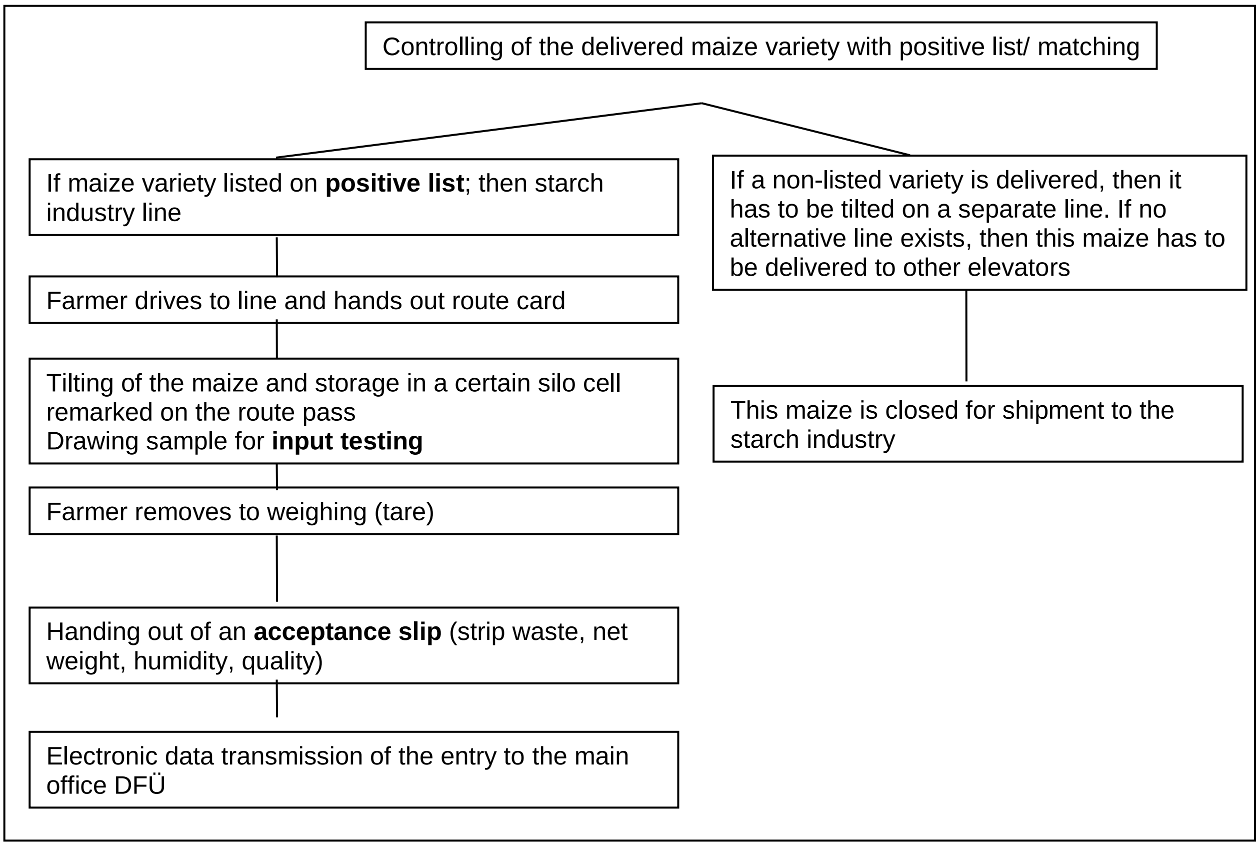
Table 28: Extra commodity costs associated with co-existence at the elevator (local segregation)

	GM	non-GM
Capacity	250,000 tons	
Amount segregation (50 %-50 %)	125,000 tons	125,000 tons
Commodity price (taken over from the previous chain level)	100.00 € per ton	112.90 € per ton
Price difference non-GM / GM	**12.90 € per ton**	
Additional transport and storage costs difference non-GM / GM	**15 € per ton**	
Aggregated additional costs non-GM *per produced unit*		**3,487,500.00€** *27.90 € per ton*

E-B. Form of transport and transport testing costs

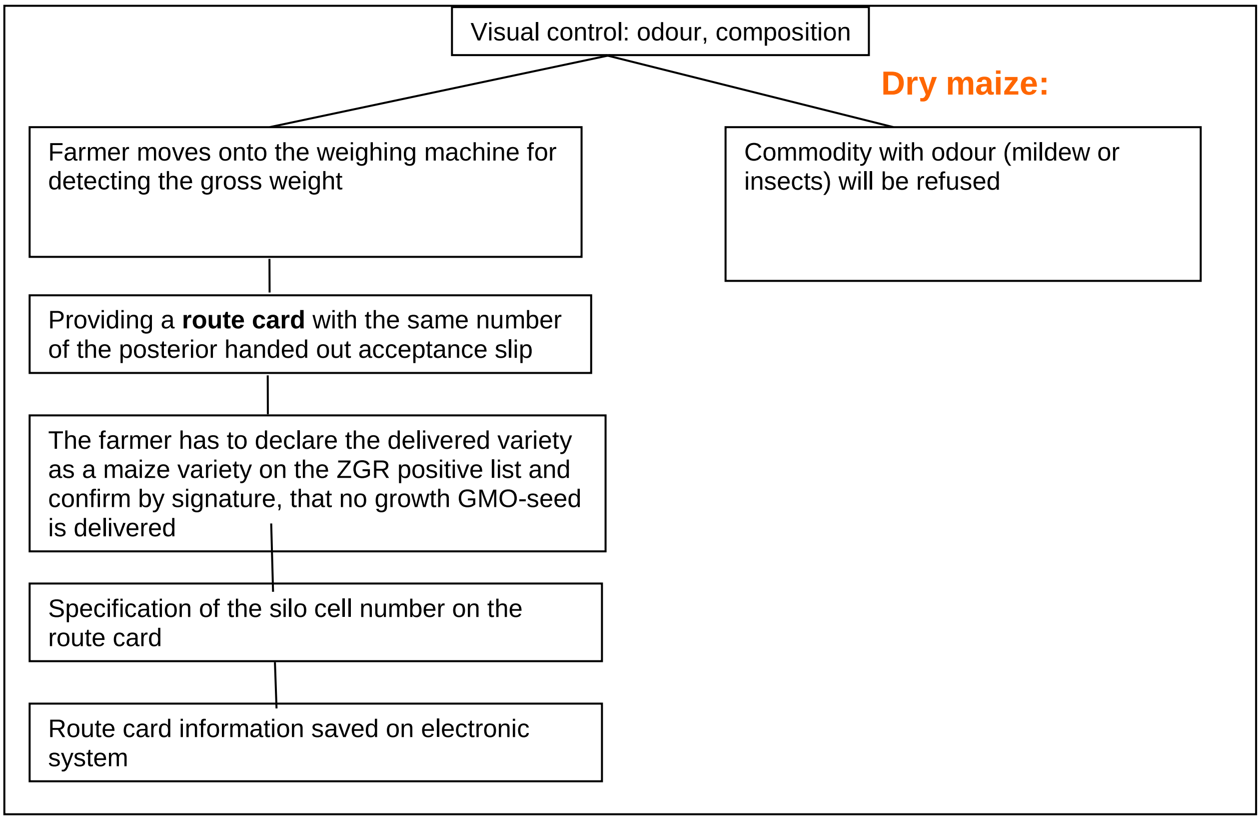
The following two figures demonstrate the procedure of the entry of maize stated by the ZGR (2004). The receipt of the commodity is shown in figure 10; the controlling of the input is shown in figure 11. The listing on elevator's positive list of the trustful varieties decides the further processing line. The route card and the acceptance slip guarantee traceability and help to avoid admixture or contamination.

Figure 10: Entry receipt at the elevator



Source: own illustration based on ZGR (2004)

Figure 11: Entry control at the elevator



Source: own illustration based on ZGR (2004)

In case of separated GM and non-GM entry and storage sites, the compulsion of testing and securing is limited on the non-GM repositories. Therefore, we define in the following cost compilation the annual testing maize amount with 125,000 tons (assumed 50 % GM maize elevated by the company**.** Currently, the application of which of the common testing types (qualitative, quantitative or quick test) and its price per application are not quite clear in common knowledge as technology and regulation are not fully developed to fix testing methodology. The assumed test type mix of quantitative PCR in combination with quick tests in different applied frequency and number of testing are gathered by hypothetical statements from interviews carried out with two crop elevator companies in 2006 (see table 29).

Table 29: Extra testing costs associated with co-existence at the elevator level (local segregation strategy)

Extra testing cost efforts (for 125,000 tons of maize)	Costs
Increased input testing quantity (Source: Own calculations based on interviews) Quick test: 5 €/test + 20 € * 0.25 hour (Labour costs for testing) → 10 € per test PCR Test: 200 €/test + 20 € * 1 hour (Labour costs for testing) → 220 € per test Total amount delivered to non-GM plant: 125,000 tons (50 % non-GM share) Share truck supply: 100 % Loading capacity truck: 25 tons Quick testing (number of tests/ testing frequency): 1/1 PCR testing (number of tests/ testing frequency): 1/10	**160,000 €**
Increased output testing quantity (ZGR 2004) Testing every 500-1.000 tons of supplied maize (= once or twice a shipment with 220 € per quantitative GMO- test)	**27,500 – 55,000 €**
Switch to internal testing procedure (ZGR 2004) Equipments acquisition (e. g. vacuuming units, sample storage)	**65,000 €**
Total costs *per produced unit*	**266,000 €*** ***2.13 € per ton***
*with average of output testing cost range of 41,250 €	

Sources: ZRG (2004), own calculation based on interviews carried out in 2006

E-C. Depreciation for additional storage and infrastructure

In E-C., additional storage costs are mixed with the incidental costs for larger transport distances as ZGR (2004) stated this composition with 10-20 € per ton. Therefore, as it is not evident which part of this figure is attributable to new storage capacities and internal infrastructure, no additional costs are gathered here.

E-D. Cleaning (Flushing) repositories

No extra costs have to be considered for cleaning repositories at the non-GM processing site for the segregated sites strategy.

E-E. Possible additional transport costs to the next level (cleaning)

It is assumed that the means of transportation of the GM site are not applied in the non-GM site respectively the cleaning of the trucks is an established proceeding in the existing quality management and does not generate extra costs.

E-F. Miscellaneous costs

No further costs are considered.

Executive Summary

The summary of the preponderated cost types is given in table 30. The allocation of the costs on the elevator chain level for the strategy of local separation is clearly weighted to the higher commodity and transport/storage costs. Total prevention costs of 30 € per ton for non-GM production site imply a share of 14.6 % of the turnover with non-GM maize and simultaneously a higher loading of 14.6 % on the wholesaling price of maize.

Table 30: Total GM prevention costs at the elevator level (local segregation strategy)

Elevator – E1	*Costs per unit*	*Unit*	*Percentage*
A. Additional commodity costs	27,90	€/t	*92,9 %*
B. Testing costs	2,13	€/t	*7,1 %*
C. Depreciation of add. storage	---	€/t	---
D. Cleaning/Flushing costs	---	€/t	---
E. Possible add. transport costs	---	€/t	---
F. Miscellaneous costs	---	€/t	---
Total additional prevention costs per unit	**30.03**	**€/t**	***100.0 %***
Price loading (basis: conventional purified maize with 205 € per ton)	**14.6**	**%**	

Processing level

In 2007 the German starch industry processed more than 4.3 million tons of agricultural crops to more than 1.5 million tons of starch products and derivates. The German Association of the Starch Industry (Fachverband der Stärke-Industrie e.V.) represents the interests of the companies. All German crushers and producers of starch products (out of maize, wheat and potato) are members of this Association. Currently, 8 companies with 14 plants and 2,000 employees are united in the Association. The companies' production structures distinguish in the range of products but also in the use of certain raw materials. While some companies concentrate on products processed out of single commodities like wheat, others provide starch products developed from all prevalent starch raw materials.

In order to gather information concerning the cost situation of the wheat starch supply chain, two interviews were carried out in 2006 (see joint wheat supply chain report). At that time a larger and a medium-sized company were surveyed. Only the larger company processes both wheat and maize to produce starch products. Because of similar requirements and production chains of wheat and maize starch processing, we omitted further interviews and adopted information and statements of the former starch processor interviews to get an applicable calculation basis. Maize chain-specific data (e. g. prices, volumes, monitoring costs and transport distances) are embedded while fundamental objects like co-existence strategies, segregation measures and costs are assumed to be the same as in the wheat starch chain calculations. In the same way, results of both interviews are incurred in the cost calculations to evade data gaps and refer the results on the German starch industry as a whole.

One larger and one medium-sized starch company were interviewed in 2006. Some production and distribution figures are just provided of the medium-sized company, because data of the larger company derives from the annual report where no specific data of starch production is available, since this is a big company with different sectors. The differentiation in separate processing strategies is done with the help of the qualitative statements of both surveyed companies.

The medium-sized starch factory has about 140 employees. The turnover is about 60 million € per year. The processed amount of wheat is 300,000 tons per year. The larger company stated that the distribution of raw materials for maize starch and wheat starch is about 1:1.5. So, for further assumptions we fix the total processed maize volume with 200,000 tons. Additionally, the processing volume is split in a 50 % - 50 % GM – non-GM segmentation in analogy to the previous levels of the value chain.

The medium-sized company stated that only domestically grown wheat is used in the company and there is no import of raw material from outside Germany. Wheat is exclusively purchased from elevators so that there is no direct purchase from farmers. So both assumptions – no maize import and no direct delivery from farm site – are transferred to the maize starch calculation model.

Further defaults are that the purified maize is delivered 50 % by ship and 50 % by truck and solely stored in silos. The storage capacity amounts to 9,000 tons which means a storage capacity of 4-5 processing days. Silos are used in a permanent mass flow without stopping and cleaning. Therefore co-existence and segregation is already difficult at this place.

The technical process starts at registration where maize is delivered by ship or truck and stored in silos. The next step in starch production is the milling process. Two bottlenecks in maize starch production are the milling process and the maize starch production process.

In the following the additional co-existence and traceability costs on the basis of the interviewed medium-sized starch processor are presented. Due to several statements of the interviewees the local segregation strategy with separated sites (one for GM production and one for non-GM production) is the only legitimate feasible and economic maintainable way to avoid admixtures. Additional costs will be predominantly additional commodity costs due to monitoring and traceability activities in the previous levels of the value chain longer transport distances and extra testing of the in- and out-coming products on the non-GM plant. This strategy would be the preferred option in economic terms in case a company owns at least two plants with the necessary preconditions of infrastructure and processing facilities. Additionally, the risk of non-GM and GM admixture could be minimized by applying this strategy.

Table 31: Set-up for the cost calculation at the processing level applying local segregation strategy

Processor level- Local segregation	
Reference	Medium-sized starch processor
Produced product(s)	Maize starch (additionally derivates)
Amount used commodities (per year) Share GM commodity	200,000 tons 50 % (Scenario: Co-existence of non-GM and GM production)
Commodity import	Yes
Separation method of processing chain	
- Local separation	**Yes (Postulated 2 plants owned by the company)**
- Spatial separation	**No**
- Time separation	**No**
Input testing	Yes (only in non-GM plant)
Output testing	Yes (only in non-GM plant)
Additional transport costs due to longer distances	Yes
Additional storage	No
Cleaning repositories	
- Cleaning	No
- Flushing	No
- Production line stop	No
Produced products non-GM (native starch, modified starch, starch derivates)	60,000 tons
Price of product (GM-standard)	495.00 € per ton (Price for maize starch stated by interviewee in 2006

Since there is a heterogeneous price structure for the different starch products, derivates and qualities the price per ton produced maize starch products was presumed with 495.00 € per ton. This price was overturned with the official production figures, turnovers and shares of maize starch products from the German Stärkeverband (see table 11). By referring to this statistical information the price for maize starch products can be settled about 55-60 % higher than the price for wheat starch products for the industrial and nutritional utilisation. As an interviewee from a wheat starch processor assumed prices of around 312 € per ton for wheat starch products, the price of 495 € per ton maize starch products seem to be very likely. This should represent the (hitherto) price for conventional production without the matter of co-existence and additional prevention efforts for non-GM starch. Carus and Müssig (2006) stated current maize starch prices of 300 to 375 € per ton and argued that the profitability of maize starch production also strongly depends on various by-products that emerge from production. For this reason higher revenues of around 500 € per ton starch products are assumed in our calculation.

Cost calculations

P-A. Commodity, certification and extra transport costs

It is assumed that the yearly processed commodity (conditioned and dried maize from the elevator) is divided into two equal partitions and delivered to the two plants of the company (see table 27). The higher price difference of 30.03 € (price loading of 12.2 %) - resulted from the calculations at the elevator level - is taken to estimate the higher commodity costs for the non-GM crop. In this calculated supply chain only the maize transport from elevator storage to the processor is considered; direct purified maize supply from farm sites is not considered as an additional possibility. Again, longer transport distances for a parallel processing of GM and non-GM on two sites are assumed. In the case that the costs for shipping would not increase too strongly when the positions of the plants are beneficial (i.e. access to inland water ways), only the higher costs for the truck transport are considered. Therefore, only a commodity amount of 50,000 tons of non-GM maize remains for the delivering of maize to the non-GM processing plant. In analogy to the wheat (starch) chain and the transport costs at the elevator level, presumed 0.1 € per km and ton wheat are allocated with a doubled transport distance of 200 km. The aggregated commodity extra costs sum up to 3,502,840 € for the analysed reference starch plant (table 32).

Table 32: Extra commodity costs associated with co-existence at the maize starch processor (local segregation)

	GM	non-GM
Total amount used per year	200,000 tons	
Amount segregation (50 %-50 %)	100,000 tons	100,000 tons
Commodity price (taken from the previous chain level)	**205.00 €/ton**	**235,03 €/ton**
Price difference non-GM / GM	**30.03 € per ton**	
Trucking amount (50 %)*	50,000 tons	
Transport distance (only trucking)	100 km	200 km
Transport costs trucking	0.1 €/km and ton	
Transport cost difference non-GM / GM	**10.00 € per ton**	
Aggregated additional costs non-GM *per produced unit (60,000 tons)*	**3,502,840 €** *58.38 € per ton*	

* Additional costs for shipping supply are not considered

P-B. Form of transport and transport testing costs

In order to produce guaranteed non-GM maize starch it is necessary to monitor the incoming commodity at the non-GM plant. The precondition for the following calculations in table 33 is that the processor is supplied by several elevators or several elevator sites. A single company as sub-supplier would minimize input testing efforts of the processor. Again only half of the totally delivered commodities have to be tested as the share of GM processing is assumed with 50 %.

Table 33: Extra testing costs associated with co-existence at the maize processor level (local segregation)

Occurring costs at the non-GM plant	Data	Source
Test cost		
Quick test: 5 €/test + 20€ * 0.25 hour (Labour costs for testing)	10 €/test	Current cognitions (5-10 €/test)
PCR Test: 200 €/test + 20€ * 1 hour (Labour costs for testing)	220 €/test	Current cognitions (150-200 €/test)
Input testing		
Total amount delivered to non-GM plant	100,000 tons	Company stated
Share truck supply	50 %	Company stated
Loading capacity truck	25 t	
Quick testing (number of tests/ testing frequency)	1/1	Company stated
PCR testing (number of tests/ testing frequency)	1/10	Own estimation
Loading capacity ship	1,000	
Quick testing (number of tests/ testing frequency)	5/1	Company stated
PCR testing (number of tests/ testing frequency)	3/1	Own estimation
Total costs input testing	**99,500 €**	
Output testing (bulk good)		
Total amount distributed products (non-GM)	60,000 tons	
Testing frequency (PCR testing)	every 12,500 tons	Company stated
Total costs output testing	**1,100 €**	
Extra personnel costs for testing measures (education and training) (0.40 € per ton and year)	**24,000 €**	Gawron and Theuvsen (2007)
Total costs	**124,600 €**	
per produced unit (60.000)	*2.08 € per ton*	

Sources: Own calculation based on interviews carried out in 2006

The respondent in the interview stated that the German milling monitoring is based on the HACCP approach. An important measure within the German milling monitoring is the permanent containment analysis after a processing capacity of 12,500 tons which includes also GMO testing. The certification after the GMO standard is an additional component according to the HACCP approach. In aggregation of input and output testing, the monitoring costs sum up to 124,600 € for the analysed starch plant, corresponding to 2.08 € per ton (referred to a total production volume of 60,000 tons of non-GM maize starch and derivates).

Gawron and Theuvsen (2007) carried out a survey to ascertain possible additional costs for the food processing industry, specialised on rapeseed and maize products. The survey included different food processing companies like the fat and margarine industry, bakery products and confectionaries but it was not focussed on the starch industry. Especially monitoring and testing strategies of the companies due to increasing GM dissemination were observed and requested in the survey. The average costs of 26 processing companies with the relevant stated cost types are shown in table 34. The average total continuous costs are stated with 1.65 € per ton.

Table 34: Additional costs for monitoring and sampling

Single cost type	Percentage of nomination (n=26)	Average cost in € per ton
Material for lab analytics	5.6%	0.14
Entry sampling	55.6%	0.08
Cleaning	5.6%	0.06
Documentation	88.9%	0.47
Personnel	61.1%	0.40
Maintenance	-	-
External lab costs	55.6%	0.50
Total		**1.65**

Source: Gawron and Theuvsen (2007)

The results of Gawron and Theuvsen (2007) show on the one hand that our calculated monitoring and testing costs seem to be in a realistic dimension although in our calculation model the form of transport has a high impact on the cost structure and differs for each company. It shows on the other hand that cost types that have the highest percentage of the total monitoring costs in our calculation are mainly often nominated by the surveyed companies (documentation, personnel and external lab costs) in the survey of Gawron and Theuvsen (2007).

P-C. Depreciation for additional storage and infrastructure

Within the strategy of an entirely separation of production sites where the production and storage capacities are on hand, no investments have to be done.

P-D. Cleaning (Flushing) repositories

No extra costs have to be considered for cleaning repositories on the non-GM processing site.

P-E. Education and training

Within the strategy of an entirely separation of production sites, where the production and storage capacities are on hand, no additional personnel education and training are necessary. Extra costs for personnel education of sampling are involved in cost type P-B.

P-F. Miscellaneous costs

No further costs considered.

Executive summary

The summary of the different cost types in maize starch production is given in table 35. The allocation of the costs at the processor level for the strategy of local segregation is clearly weighted to the higher commodity and transport costs. Total prevention costs of 60.46 € per ton starch for non-GM production imply a share of 6.1 % of the total maize starch turnover of the company (non-GM and GM maize starch) and simultaneously a higher loading of 12.2 % on the current market price of maize starch in order to achieve co-existence.

Table 35: Total GM prevention costs at the maize starch processor level (local segregation strategy)

Processor – P1	*Costs per unit*	*Unit*	*Percentage*
A. Additional commodity costs	58.38	€/t	*95.4 %*
B. Testing costs	2.08	€/t	*4.6 %*
C. Depreciation of add. storage	---	€/t	---
D. Cleaning/Flushing costs	---	€/t	---
E. Production stop costs	---	€/t	---
F. Education and training	---	€/t	---
G. Miscellaneous costs	---	€/t	---
Total prevention costs	**60.46**	**€/t**	***100.0%***
Price loading (basis: conventional maize starch and derivates) 495 € per ton	**12.2**	**%**	

Finally, the economical impact of the processing strategies 1-3 (see chapter 4.2.6) on additional costs in the case of co-existence is considered for the example of wheat starch. The cost structures of the three strategies are quite different and depend on the basic conditions and economical decisions of each starch company. To get an overview on the effect of this strategic impact, the conducted calculations for wheat starch processing are confronted with our maize starch chain results in table 36.

Table 36: Comparison of costs occurring by different co-existence strategies and processed starch products at the processor level

Processor level (starch medium sized company)				
	Maize starch	**Wheat starch**		
Produced amount (tons)	60,000	100,000		
Product price (€ per ton)	495.00[2]	312.50[1]		
Strategy	**1 Local segregation**	**1 Local segregation**	**2 Spatial specialization**	**3 Temporal specialization**
Plants	2(+)	2(+)	1	1
GM-risk[3]	low	low	medium	high
- P.-A. Commodity	3,502,840 €	2,427,500 €	2,052,500 €	2,052,500 €
- P.-B. Monitoring	124,600 €	151,090 €	777,170 €	777,170 €
- P.-C. Additional storage	--	--	88,330 €	88,330 €
- P.-D. Flushing	--	--	--	90,000 €
- P.-E. Production stop	--	--	--	312,900 €
- P.-F. Education/Training	--	5,000 €	10,000 €	15,000 €
- P.-G. Miscellaneous	--	--	989,330 €[4]	-- €
Prevention costs (total)	**3,627,440 €**	**2,583,590 €**	**3,917,330 €**	**3,335,900 €**
Price with prevention costs	555,46 €	338.34 €	351.67 €	345.86 €
Price loading	+ 12,2 %	+ 8.3 %	+ 12.5 %	+ 10.7 %

1 Price stated by interviewee 2006
2 Price interpreted by an interview stated 60 % loading for starch products (incl. derivates)
3 Evaluated potential admixture risk
4 Investment in new production line

A comparison of the different products and strategies shows that the local segregation is the possibility with the lowest additional costs and the lowest evaluated GM admixture risk because of the strict segregation of sites. Of course, the decision for a certain strategy in the case of increased co-existence depends on the basic conditions, economical and structural possibilities of the company and the current situation of GM acceptance and awareness of the next chain level (traders, retail and especially private consumers). The higher price loading of the non-GM maize starch (12.2 %) compared to wheat starch (8.3 %) within strategy one results from different commodity prices and amounts but also from different data sources and assumptions (therefore lower monitoring costs are figured out in case of wheat starch).

Conclusion

This report analyses the feasibility and costs of co-existence by GM and non-GM production and calculates the costs of essential measures to avoid admixture of GM and non-GM starch products along the German maize starch supply chain. The information was conducted throughout existing case studies and publications or public information and interviews conducted with experts along the maize starch supply chain. The information sources used for the cost calculations along the supply chain are shown in table 37.

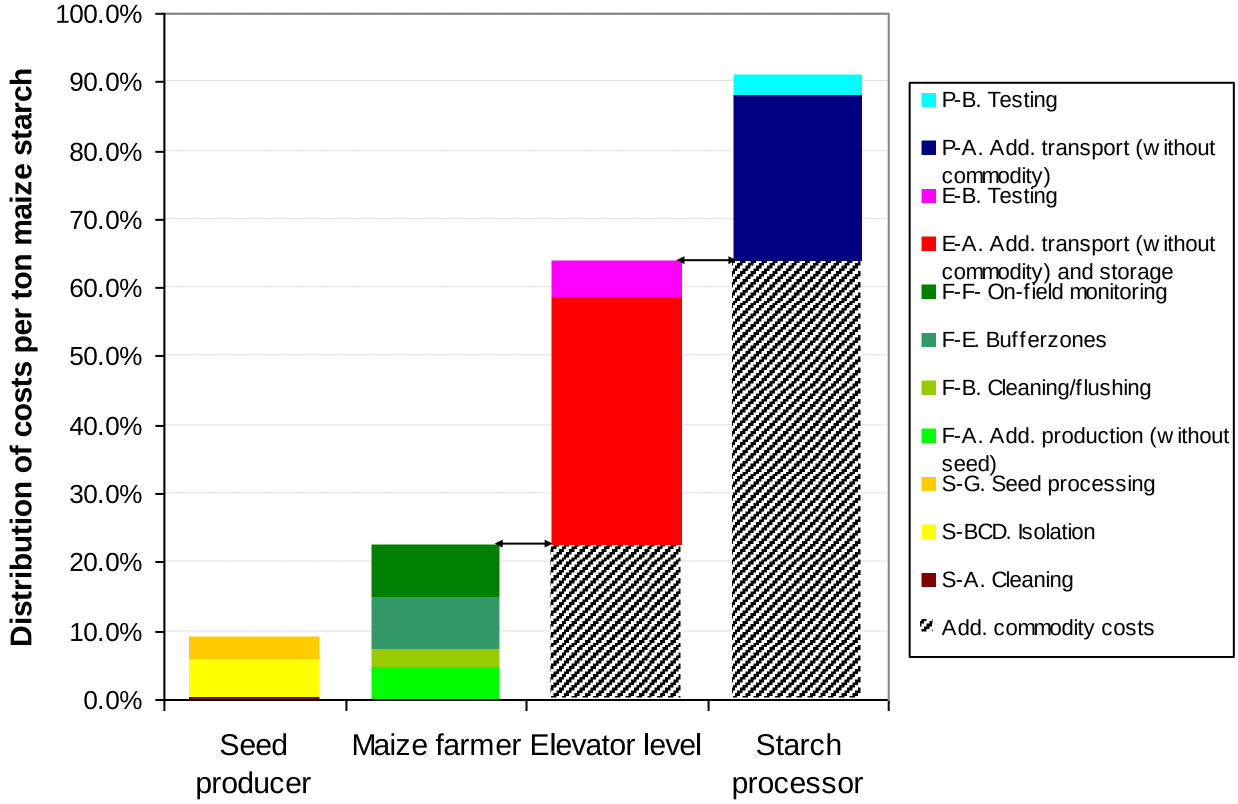
Table 37: Information sources used in the case study

Chain Level	Information	Most important Sources/Studies	Most important Presumptions
General	Compulsory conditions and assumed situation		▪ 50 % GM situation ▪ Adherence of compulsory GM thresholds (0.9 %) ▪ Respecting GM opportunity costs as price loading on non-GM
Seed producer	Costs of co-existence and economical benefits of GM seed production and processing	▪ Messéan et al. (2006) ▪ Menrad and Reitmeier (2006) ▪ Kalaitzandonakes (2008)	▪ Technological fees for GM seed ▪ 50 % regional GM adoption rate ▪ Squared 5 ha seed fields
Farmer	Costs of co-existence and economical benefits of GM crop production	▪ Messéan et al. (2006) ▪ Menrad and Reitmeier (2006)	▪ Higher yield Bt-maize ▪ Price premium non-GM ▪ Buffer zones as isolation measure ▪ On-field monitoring ▪ Direct elevator supply after harvest
Elevator	Cost structure and applied strategies of co-existence and traceability	▪ Interviews agro-elevators (2006) ▪ ZGR (2004)	▪ Drying at the elevator (drying and purifying not conducted at farm level) ▪ Large sized company (Local segregation possible) ▪ Input and output testing ▪ No import situation
Starch processor	Cost structure and applied strategies of co-existence and traceability	▪ Interviews starch industry (2006) ▪ Gawron and Theuvsen (2007)	▪ Local segregation possible ▪ Input and output testing ▪ German milling monitoring (HACCP) already installed ▪ No import situation

The potential risk of unintended GMO admixture on seed and farm level is considered taking into account the results of Messéan at al. (2006) as well as Menrad and Reitmeier (2006) and transferring them to the German situation if required. Released results and intermediate data were used for the cost calculations at the seed producer and farm level. For the elevator level, a statement of an important agricultural elevating and trading co-operation in Germany (ZG Raiffeisen) from 2004 was used to appropriate the current attitudes and approaches in co-existence issues on this level. Here, the loss of acceptance from consumers' side and the current political situation in Germany regarding GM issues inhibits a parallel treatment of GM and non-GM crops for this company. The considered cost structure is not geared to co-existence measures but to prevention of the non-GM status of the elevated and traded crops. To ascertain costs at the processing level, statements and data were extracted from interviews with starch companies in the background of data collection for the wheat starch supply chain. The starch processing industry in Germany is dominated by around 10 big companies of which five companies process maize starch besides other starch commodities. The production and structural framework of the starch processing industry, in particular incidental monitoring efforts, were transferred from interviews with (wheat) starch processing companies complemented by data out of a survey organised by Gawron and Theuvsen (2007). Several assumptions have to be implemented to conduct the cost calculation and get meaningful and realistic results for the whole maize starch chain in Germany.

Finally the cost structure and results of the co-existence costs of maize starch are summarized in figure 12. The distribution chart respects all occurring cost types gathered in the previous chapters for the four chain levels: seed producer (yellow-coloured), farmer (green-coloured), elevator (red coloured) and starch processor (blue coloured). The aggregation of all coloured blocs furnishes the total additional costs caused by co-existence and traceability. The streaked blocs represent the transferred additional commodity costs because of non-GM premium prices to next level of the value chain.

Figure 12: Distribution of costs per ton maize starch along the supply chain



The figure describes the percentage of each cost type on one ton of maize starch at the end of the considered maize starch chain. All costs in one level represent the additional commodity costs at the following level. As example all costs that occur from the seed level (S-A.) up to the farm level (F-F.) are equalized with the additional commodity costs for non-GM maize at the elevator level (here aggregated 31 %). So the distribution of costs on the four chain levels is easy to overlook. While 42 % of the costs are imposed on the elevator level, the processor has to raise 27 % of additional costs besides the higher commodity prices. Altogether it is evident that in case of a co-existence strategy, stakeholders on all levels of the value chain are faced with strong economical impacts to preserve non-GM products in this value chain.

4.3 Maize for silage: the case of Denmark

4.3.1 Supply Chain Description

In Denmark about 5,5 %, of the total arable land is used for growing maize. The maize produced in Denmark is used for silage only ´however a few farmers have experimented with maize for ripeness within the last years. A few hectares of GM maize have been grown in Denmark for experimental purposes. At current two production systems exists, a conventional one and an organic one. No seed production takes place in Denmark.

Due to climatic reasons it has not been possible to grow maize to maturity for feed or for human consumption. The cold climate in the northern part of Europe is to some extent beneficial for some kinds of maize growing as this part does not struggle with the same persistent pests in the maize as do growers in Spain and other southerly located countries. The GM-maize that has been introduced in Europe so far has been with traits of resistance against pests. As these pests are not naturally occurring in Denmark, the interest in growing these crops has so far been limited. The general interest in growing maize has however been increasing over the years and roundup resistant maize may be introduced within a few years. In figure 13, the development in the cultivation of maize as fodder (silage) is shown.

Figure 13: Development of the acreage of maize for silage in Denmark (in ha)

The main reason for the large growth in the amount of maize grown is due to the fact that new varieties of maize can be productive in the northern hemisphere and are easier and thus cheaper to handle compared to fodder beets. In the Danish case this has meant a large substitution away from fodder beets towards maize for silage.

At current there is no GM maize production in Denmark, but a co-existence regulation is in place, which must be followed by the GM grower. The regulations are based on “good farming practice” together with crop specific isolation distances, cleaning of machinery, education and payment to a compensation fund.

When introducing GM maize in Denmark the main critical point is to make sure that there is no admixture in the seeds supplied, which is controlled by “Plantedirektoratet” (Danish authority) and of course to avoid contamination when sowing. Once it is certain that the right seed is in the ground the critical points are very few. The isolation distances to maize on neighbouring farms are not seen to be an issue of economic relevance and can be handled within the normal crop rotation planning.

In many ways the maize plant can be viewed to be an optimal GM plant in Denmark because it does not have any wild relatives in nature and therefore the chances of cross contamination with other plants will be limited. Even if some seeds should accidentally spread the chances of a wild population of maize will be very limited.

In the future in order to minimize the risks of admixture a farmer will, if he chooses to grow GM maize report to “Plantedirektoratet”. Then the particular field will be visually presented on the homepage of this authority. This way everyone will know where the GM maize is grown.

Farm structure

Mainly dairy farmers grow maize to be used as feed. The majority of these farmers has their own storage facilities and will store the silage maize on the farm after the harvest. Therefore no central storage/elevation will take place, reducing the chance of admixture of GM / non-GM. The only trade that is related to silage is between neighbouring farmers who may arrange to buy some silage, but no actual market exists. Therefore the maize silage chain is only related to the individual farms which grow the maize and in some situations extends to close by farms.

As the maize is only used for animal feed there is no labelling issue

With the current framework the main actors are the farmers and the contractors. For the majority of farmers, having their own equipment to deal with the harvest and processing of silage is not economically feasible, therefore the majority of the maize harvesting is done by contractors.

Physical assumptions related to farmers

Farms growing maize for silage have an overage maize acreage of approx. 25 hectares (Danmarks Statistik 2007), which may be distributed among a number of fields. The economic calculations are therefore based on an average maize acreage of 25 hectares per farm yielding an average of 37 tonnes per hectare (Danmarks statistik 2007).

In the calculations it is assumed that farmers will choose to grown either GM or non-GM maize in any one year. It is also assumed that harvesting is done by a machine combination consisting of 1 forage harvester and 2 tractors/trailers for transport of the harvested material from field to farm. Each contractor machine combination will handle 500 hectares per harvesting season (Kjeldahl, 2008).

4.3.2 Extra costs

If GM maize is introduced the farmers may have to pay an extra premium for the machine pools' services. This is due to the extra costs that the contractor will have to endure. If some farmers would choose to grow both GM and non-GM maize there would be extra costs associated with extra storage capacity. This is not likely as farmers will tend to specialize in only one type crops as is the case with organic contra conventional growing.

Administration

In case GM is introduced there will be some extra time associated with the paperwork that has to be filled in and send to the Plant directorate. The actual cost for the farmer is however open for discussion. The farmer has already filled in the same paperwork related to get his farm subsidy. It is therefore argued that no extra costs should adhere to the administrative handling of GM.

Transport

Vehicles used for transporting both GM and non-GM maize will have to be cleaned. Eventually it will be sufficient to clean the machinery after GM transportation. As the majority of maize is being harvested by contractors that are likely to process both GM and non-GM, the operators of the machine pools will have higher costs associated with the work. This will lead to higher costs for their services. With the present regulation in Denmark any contractor who offers its service is instructed to state if his equipment is used for GM material. This may cause some customers to reject a machine pools services and some machine pools will eventually specialize in non-GM maize.

If a machine pool chooses to supply services related to both GM and non-GM main extra costs will accrue due to cleaning of machinery and to covers for the tractor trailers. At current there is no legislation dictating certain forms of transport related to GM seeds or GM crops (Plantedirektoratet, 2006). However spilling of GM material is strictly forbidden, it is therefore assumed that all trailers will have to be equipped with special covers. The cost of suitable cover for a tractor trailer is estimated to be €1300. This cost is indifferent to the scenario. With a five year depreciation this comes to € 260 per trailer per year.

A contractor wishing to handle GM may also have to pay a higher premium in insurance. It has not been possible to estimate these costs but they are expected to be minimal.

Cost of cleaning

When the machine combination has been used for GM maize it will have to be cleaned. The cost doing this is estimated to be €45 (3 machine units * 0.5 hours/unit * 30€ / hour). This will have to be done every time the equipment moves from a GM farm to another farm, GM as well as non GM (table 38).

Table 38: The yearly cost of cleaning equipment that are handling GM maize.

Scenario	10 %	50 %	90 %
Cleaning equipment after use on GM farm	€ 90	€ 450	€ 810

The cost of cleaning is variable which and hence the total cost of handling GM material quite naturally rises when more is handled.

Training of personnel

In order to handle GM material a special education is needed. The farmer or contractor who are responsible for the overall planning on the farm will have to attend a two day seminar at a cost of €660. Assistant personal at the farm and personnel employed at the contractor will have to attend a one day seminar at the cost of € 165. If the person attending the seminar is employed there will also be the cost of labour witch is 30€ in 7 hours for a full days work coming to a total of € 210 (table 39).

As contractors employ many young people on short contracts it is assumed that the cost of a new licence will need to be renewed every third year. This comes to a yearly cost of € 125 and will be independent on the level of GM cultivation.

Table 39: The yearly cost training personal to legally handle GM material.

Scenario	10 %	50 %	90 %
Licence to handle GM	125	125	125

The cost is fixed and therefore it does not vary with the amount of GM handled. This means that the pr tons cost of handling GM material decreases when the amount rises.

4.3.3 Total costs

In table 40 the extra total costs of handling GM material is presented. The data is presented for the three different GM scenarios set up for maize. The calculations are based on contractor handling on average 500 hectares yearly per machine combination with an average yield of 37 tonnes per ha. and an average farm maize acreage of 25 hectares. In the calculations the equipment is cleaned every time the equipment is moved from a GM harvesting operation.

Table 40: Extra yearly cost of segregation GM and non-GM maize (500 hectares maize handled)

	10% GM	**50% GM**	**90 GM%**
Segregation			
Cover for trailer	260	260	260
Cleaning and flushing			
Cleaning equipment after use	90	450	810
Compensation fund*	660	3.300	5.940
Training personal			
Licence to handle GM	125	125	125
Benefits			
Plant production savings ÷ extra price GM seed	500	2.500	4.500
	10%	**50%**	**90%**
Total for 500 hectares of GM silage maize	***€ 635***	***€ 1.635***	***€2.635***

* Compensation fund: 13.2 €/hectare GM crop.

In table 41, the costs pr ton for keeping GM and non-GM material segregated are illustrated for different adoption rates and cost allocations either to the total maize area, the non GM maize area or the GM maize area.

Table 41: The cost of segregation pr ton maize silage

Theoretical distribution costs	Total maize	GM	non-GM
10% GM	0,03	0,34	0,04
50% GM	0,09	0,18	0,18
90% GM	0,14	0,16	1,42

From the table it can be observed that the cost of ensuring segregation is modest in all cases. When handling GM in large amounts the pr ton price goes down which is due to the fixed costs related to the investments needed and the training of personnel. In case of a 90% GM adoption rate and allocation of the segregation costs only to the non-GM maize the costs seems relatively large. In real life the extra costs of segregation would probably not all be distributed to the non-GM maize.

5 Conclusions

In this report, we provided information about the co-existence costs of three different maize supply chains in Europe: grain maize for feed (Switzerland), starch maize (Germany) and maize for silage (Denmark) (see table 42).

1. Farm level:

As far as the maize for silage supply chain (Denmark) is concerned, we can conclude that this supply chain is rather simple and the risk of admixture is very low. The most critical point in the chain is to avoid admixture during sowing. Contractors are harvesting the majority of maize in Denmark meaning that equipment has to be cleaned when shifting from GM to non-GM operations. After harvesting the only critical point in terms of admixture is the transportation of the maize. Therefore, the cost associated with segregation is limited to cleaning of equipment and to possible investments in covers to trailers and licences to handle GM material. However, the most important cost category for the maize for silage supply chain in Denmark is the very specific issue of the national compensation fund which requires GM farmers to pay 13.2€/ha GM crop. The fee for this compensation fund amounts for almost 80% of the total co-existence costs of the maize for silage supply chain (farm level).

Compared to the situation in Denmark for maize silage, the cost structure of the co-existence costs for the grain maize (Switzerland) and the starch maize (Germany) supply chains are quite different. In both case studies, the co-existence costs amount approximately 10 – 13% of the maize producer price paid in the respective countries. The total co-existence cost at farm level in the German case study is approximately half of the co-existence costs of the Swiss grain maize case study (Germany: 123 €/ha; 12.9€/t, Switzerland: 227.2 €/ha; 24.4€/t). In both case studies, the additional production costs are responsible for approximately 40% of the total prevention costs. The difference in the co-existence costs is on the one hand due to generally higher cost and crop price levels in Switzerland. On the other hand, the rather small-scaled agricultural structure in Switzerland together with an assumed premium price for IP maize resulted in higher opportunity costs for buffer zones or discard widths respectively. Furthermore, the opportunity costs for the discard / buffer zone and monitoring costs are important cost drivers at farm level (share of total prevention costs at farm level: Germany 24.2% / 24.6%, Switzerland 28.6% / 22.6%).

Therefore the crucial question with respect to additional prevention costs are the legal requirements for isolation distances on the one hand and on the other hand how the different markets will react on the introduction of GM commodities and whether IP farmers will succeed in realising a price premium for guaranteed non-GM raw material.

2. Elevator and Processor Level

While we found a quite different structure of the co-existence costs on farm level, the differences between the Swiss and the German case study are quite low at the elevator and processor level. In both case studies, the additional commodity costs are by far the most important cost factor (93-95% in Germany, 79-87% in Switzerland). Only 5-7% or 13-17% respectively of the total prevention costs are due to testing activities. The testing costs in Switzerland are three times the German testing costs. The reason for this are the higher labour costs in Switzerland (50 €/h vs. 20€/h) and the assumed quantitative testing programme of testing every lot leaving the elevator. In contrast to this, in the German case study, output testing is assumed to be done every 500-1,000 tons at elevator level and every 12,500 tons at processor level. However, we need to stress, that e.g. the German starch maize processor has an annual processing capacity of 200,000t compared to 30,000t of the Swiss feed mill. Furthermore, processing feed in Switzerland for farms with an average farm size of 17ha UAA is in terms of scale quite different to producing starch for the industry. Thus, the issue of scale is one important factor to be considered when interpreting the differences in the testing costs found in the two case studies.

Furthermore, we learnt from the stakeholder interviews that operators dealing with non-GM commodities might put first priority in guaranteeing non-GM products to their costumers. Therefore depending on the level of uncertainty, the individual risk perception and the GM sensitivity of the buyer, more or less efforts might be put in testing and monitoring. This is particularly relevant, as most stakeholders interviewed have had so far almost no experience in operating GM commodities. It can be expected, that under a co-existence scenario in the mid-term these testing and monitoring programmes will change to more efficient and cost effective solutions.

Table 42: Comparison of the aggregated additional prevention costs per case study

	Switzerland	**Germany**	**Denmark**
Case study	Grain maize	Starch maize	Maize for silage
FARM level (€/t)	**24.4**	**12.9**	**0.18**
Add. production costs	39.9%	42.8%	--
Cleaning	--	8.4%	10.9%
Isolation/discard zone	28.6%	24.6%	--
Monitoring	22.6%	24.2%	--
Indicative insurance	8.9%	--	--
Compensation fund	--	--	79.8%
ELVATOR level (€/t)	**43.3**	**30.03**	**--**
Add. commodity costs	79.5%	92.9%	--
Testing	17.3%	7.1	--
Cleaning	3.2%	--	--
PROCESSOR level (€/t)	**86.5**	**60.46**	**--**
Add. commodity costs	87.1%	95.4%	--
Testing	12.9%	4.6%	--

As concluded in Deliverable 2.3 of Workpackage 2 of the Coextra project, the question “How to handle co-existence?” is hypothetical because the consumers in Europe have still a negative attitude toward GMO and there is almost no demand for GMO commodity. It is obviously difficult for the stakeholders to assess a situation which is not real yet. Therefore, information provided from the supply chain actors was quite different and sometimes contradictory: For some supply chain actors, GMO-commodities are just another quality and can be processed like any other quality with an adapted quality assurance system. Other stakeholders see no way to ensure co-existence of GM and non-GM commodities without additional investments (e.g. for parallel production in one site, separated factories or additional storage facilities). The production lines are usually designed to process different products and qualities. If any isolation of processing is necessary, then investments for new lines are indispensable.

The case studies show that the qualification of elevators and processors in terms of infrastructure and resources endowment to operate GM and non-GM commodities in parallel is quite different. In countries where the concentration process at the elevator and processor level is low, this might be an opportunity for specialisation of companies for operating either GM or non-GM commodities. However, depending on the market share of GM-commodities, this also might be the first step to accelerate structural change in the sector.

In general, we can conclude on the basis of the case studies conducted, that every actor and supply chain level will be economically affected under a co-existence scenario. As the additional commodity costs are the most relevant cost category at the elevator and processor level, the farm level borne co-existence costs are of particular importance. In this respect, the most determining factors are the isolation measures to ensure the 0.9% threshold of GM admixture, the threshold determined for “non-GM” seeds, the farm structure and the regional penetration level of GM commodities, consumers willingness to pay for non-GM commodities etc. which all finally influence the price premium between GM and non-GM commodities.

The concept of our study assumes that the prevention costs of the previous supply chain level will be entirely transferred to the next supply chain level. In other terms, the buyer is willing to pay the additional prevention costs of the previous supply chain level. This concept is completely justified in a situation where information how the markets in Europe will react is quite scarce. Nevertheless, it needs to be highlighted, that buyers will try to get through lower commodity prices. This will require adaptation strategies of those supply chain actors with the lowest market power in order to be able to supply IP produce at least costs. Countries or regions respectively with a non-GM strategy might benefit from such a situation provided they are able to deliver the requested qualities at lower prices.

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