Bio-based and Applied Economics 3(3): 187-204, 2014
DOI: 10.13128/BAE-15017

Review Article

Biotechnologies and agrifood strategies: opportunities, threats and economic implications

Justus Wesseler

Wageningen University, Hollandsweg 1, 6706KN Wageningen, The Netherlands

Abstract. The production of food employs different kinds of biotechnologies, some of which are more controversial than others. The public and the agrifood sector have developed a number of responses to address their concerns about biotechnologies considered controversial. In this contribution the different strategies chosen by the agrifood sector in the EU in response to the introduction of new biotechnologies in the agrifood complex will be discussed. The contribution concentrates on the example of the introduction of genetically engineered crops and the strategic responses by the EU food industry, namely food processors and food retailers. The contribution concludes with an outlook on the future of the EU agrifood complex.

Keywords. Biotechnology, regulation, technical change.

JEL Codes. Q1, L5, L66

1. Introduction

Food processing without biology is nearly impossible. The processing of primary food products such as grains to higher quality products via fermentation uses enzymes. This is one of man's oldest food processing technologies and has been claimed to be the origin for domesticating grains (Katz and Voigt, 1986). Man's knowledge about food and food processing has improved and today we have a wide range of biotechnologies available to help us to cultivate and process agricultural products. In particular advances in molecular biology have generated new biotechnologies and will continue to do so. These new technologies offer opportunities for the agrifood sector and society at large, allowing for the reduction of agriculture's environmental footprint; for increasing food supply, and the diversity of food products available (Bennett *et al.*, 2013).

While a wide range of opportunities for using biotechnologies are available, views about their benefits differ substantially. The recent debates surrounding the introduction of Vitamin A enriched rice (Golden Rice) (Wesseler and Zilberman, 2014) and the approval of the genetically engineered (GE) maize 1507 for cultivation in the European

* Corresponding author: justus.wesseler@wur.nl.

ISSN 2280-6180 (print)
ISSN 2280-6172 (online)

Union (EU) (Rabesandratana, 2014) serve as examples.[1]

The differences in views are often correlated with the distribution of the benefits and costs of the technology (Graff *et al.*, 2009) that are unevenly distributed between different sectors of our economies and between economies (Smyth *et al.*, 2014). Insect resistant crops reduce pesticide use to the disadvantage of the agriculture chemical industry, but benefit the companies holding the property rights on the new seed products (Bennett *et al.*, 2013). Countries with a less restrictive regulatory system in agriculture food production might benefit more from biotechnologies increasing their comparative advantage (Qaim, 2009). Simultaneously, food markets become more differentiated in a response to demands for special food items such as "GM-free" (GM = genetically modified) dairy products providing new opportunities for the agrifood sector.

In parallel to the development of new biotechnologies, the regulatory environment has changed. Concerns about environmental and health impacts of existing and new technologies have become an important part of regulations (Wesseler and Kalaitzandonakes, 2011). The regulatory environment in Europe has also been influenced by the establishment of the EU and its enlargement (Smart *et al.*, 2014). Further, different stakeholder groups try to influence regulations on GMOs depending on their individual gains, losses and beliefs (Graff *et al.*, 2009).

In this contribution the different strategies chosen by the agrifood sector in the EU in response to the introduction of new biotechnologies in the agrifood complex will be discussed. The contribution concentrates on the example of the introduction of genetically engineered crops and the strategic responses by the EU food industry.

The contribution unfolds as follows. First, a brief EU history on GE food and the regulatory regime will be provided followed by a discussion and assessment of the GM-free response strategy responses of the EU food industry. The assessment mainly concentrates on food processors and food retailers and concludes with an outlook on the future of the EU agrifood complex.

2. EU history on genetically engineered products

GE food product developments until 1999

The development of the recombinant DNA technology in the early 1970s was the start of modern biotechnology (Tramper and Zhu, 2011) (see Table 1). The Bayh-Dole act of 1980 in the United States (US), which provided universities and other forms of organisations with the right to exploit patents that had been obtained with public funding, has been seen as key for innovations in modern biotechnology (Stevens, 2004). Some of the first successful products using rDNA technology were a vaccine for swine diarrhoea in 1982 by the Dutch company Intervet and the production of human insulin for diabetics from GE bacteria by the US company Eli Lilly. Since 1984, the Dutch Company Gist-Bor-

[1] For convenience, applications of modern biotechnology in agriculture will be abbreviated with GE for genetically engineered. The term "genetically modified organism" or GMO will be used when referring to EU policies. The differentiation is relevant, as according to the definition of a GMO by the European Union, strictly (scientific) speaking they would not exist, except one rejects evolution and follows a "creationist onthology" and hence the term is a political construct (Herring, 2008).

Table 1. Important events in the EU history of modern biotechnology in agriculture.

Year	Event
1973	Development of rDNA technology
1980	Bayh-Dole act, providing intellectual property right to organisation and individuals from inventions with public funding in the US.
1982	Vaccine against swine diarrhoea and production of human insulin (US) by means of rDNA technology
1986	First cases of bovine spongiform encephalopathy (BSE) in cattle in the UK reported starting the "mad-cow-disease" crisis in the EU.
1986	OECD publication on "Recombinant DNA safety considerations", so called "Blue Book", setting international standards for safety assessments.
1990	Hermann the bull, the first genetically engineered bovine, was born. Female off-springs of Hermann the Bull would produce milk with a high content of lactoferrin to be used to strengthen the immune system of humans. Product developed by Pharming Group N.V., The Netherlands
1991	Report about HIV contaminated blood samples knowingly be distributed in France published and together with the handling of the "Mad Cow Disease" undermining public trust in regulatory health safety systems in the EU.
1995	Flavr Savr tomato introduced by Calgene (US) but withdrawn in 1999.
1996	Dolly, a cloned sheep was born.
1998	First GE crop approved for cultivation in the EU (MON810)
1999	Study on mortality effects of pollen from genetically engineered plants on larvae of Monarch Butterflies published in May 1999 in *Nature*.
1999	Environmental Council of the EU calls for a temporary ban of approvals of GMOs ("quasi moratorium") in July 1999.
1999	Apad Pusztai claims negative effects of GM technology on the biology of rats in August 1999.
2000	StarLink Case: traces of StarLink corn, not approved for human consumption were found in food products (taco shells) in the US.
2000	Friends of the Earth Europe launches an EU wide campaign "calling for a halt to the GMO pollution of food and the environment".
2001	EU Directive 2001/18 on the deliberate release of GMOs into the environment published. Includes the safeguard clause.
2002	European Food Safety Authority established. Tasks among others the environmental and food safety assessment of genetically modified organisms (GMOs).
2003	Regulation 1830/2003 on traceability and labelling of GMOs published. Introduces the 0.9% threshold level for labelling.
2003	Recommendations by the European Commission on guidelines for the development of national strategies and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming.
2009	Study on the effect of Bt maize on the two-spot ladybird published and used as an argument by the German and French government to ban the cultivation of MON810.
2009	Lisbon Treaty enters into force on December 1, 2009. Among others some changes in the approval process of GMOs including explicit deadlines for different steps.
2011	Regulation (EC) No 1331/2008 of the European Parliament and of the Council establishing a common authorisation procedure for food additives, food enzymes and food flavourings
2011	Regulation on low-level-presence of unapproved events establishing a 0.01% threshold for feed. Zero tolerance level for unapproved events for food remains published in June 2011.
2011	Judgement on the content of GM pollen in honey by the European Court of Justice starting a debate on how to measure GMO content in food in September 2011.
2012	Study published by Seralini *et al.* claiming toxic health effects of herbicide resistant maize as well as glyphosate. Used by the Government of France to invoke the safeguard clause.
2013	TTIP negotiations launched. GMO approval policy in the two regions important part of the agenda.

cades (now DSM) started to insert the bovine chymosin gene in yeast cells, which allows for cultivating the yeast in large fermenters to be used for cheese production. In the late 1980s, the technology was adopted by cheese producers in Switzerland, followed respectively by producers in The Netherlands, Germany, and France, in 1992, 1997, and 1998. Parallel, applications for enzymes produced from GE bacteria for bakery products have been introduced (Tramper and Zhu, 2011).

The first GE food product, the FlavSavr tomato by Calgene, was introduced in 1996 in the UK. The FlavrSavr tomato has been an interesting case: it was developed by Calgene and introduced to the UK under a licensing agreement by Zeneca in 1996, and was removed from the market in 1999. The tomato paste derived from this tomato was labelled and sold by Safeway's and Sainsbury, and initially even outsold alternative tomato paste brands. Sales drastically declined in 1998, and in 1999 both supermarket chains delisted the product. The problem started according to Bruening and Lyons (2000) with the broadcasting by Dr. Arpad Pusztai in 1999 about his claim that genetic engineering may have effects on the biology of rats, which resulted in demand declining. Safeway and Sainsbury not only removed this tomato from their shelves, but also declared that they would refrain from selling any GE food in their stores including animal products derived from animals fed with GM feed (ibid).

The first transgenic maize crop was introduced in the US in 1995, followed by GE cotton, soybeans, oil seed rape, and corn (Smart *et al.*, 2012). The first GE maize approved for cultivation in the European Union was the event MON810 by Monsanto. Cultivation first started in 1998 in France and Spain, a year later Portugal followed, and Germany followed in 2000 (see Table 2). While MON810 was approved under the regulations for novel food, regulations changed in the early 2000's after a temporary ban on approvals, the so called "quasi moratorium". France and Portugal implemented a temporary ban in the early 2000's (Brookes, 2007). France and Germany did ban cultivation of MON810 from 2007 and 2008 onwards respectively.

The "quasi moratorium" and policy developments since

In June 1999 at the meeting of the environmental council five member states, namely Denmark, France, Greece, Italy and Luxembourg declared they would block new approvals of genetically modified organism (GMOs) until the European Commission proposed additional legislation governing their introduction (EU Environmental Council, 1999). Those five member states asked for establishing a more transparent framework for the approval of GMOs including a risk assessment that considers explicitly the specificities of European ecosystems, a monitoring scheme and a positive labelling policy. Those member states saw this as being important steps to restore public and market confidence; otherwise, "they will take steps to have any new authorisations for growing and placing on the market suspended." (ibid).[2]

Similarly, Austria, Belgium, Finland, Germany, The Netherlands, Spain, and Sweden asked for a thorough risk assessment of GMOs and in particular intended "not to author-

[2] In particular many people lost their confidence in government regulators since the mid 1980's because of the BSE scandal, HIV contaminated blood products in France, and other such incidents.

Table 2. Cultivation of Bt maize in the European Union (ha).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Spain	22,000	30,000	20,000	25,000	25,000	32,000	58,000	53,225	53,667	75,148	79,269	76,057	76575	97325	116306
France	2,000	<2,000	<500	0	0	0	0	492	5,000	21,147	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	150	1,290	5,000	8,380	6,480	4868	5090	3080
Portugal	0	1,000	0	0	0	0	0	750	1,250	4,500	4,851	5,094	5500	7723	9278
Germany	0	0	<500	<500	<500	<500	<500	342	947	2,685	3,171	0	0	0	0
Slovakia	0	0	0	0	0	0	0	0	30	900	1.900	875	1740	761	0
Romania	0	0	0	0	0	0	0	?	?	350	7,146	3,344	823	588	217
Poland	0	0	0	0	0	0	0	0	100	320	3,000	3,000	3500	3900	4000
Total	24,000	>31,000	>20,000	>25,000	>25,000	>32,000	>58,000	54,959	62,284	110,050	107,717	94,750	91193	115386	133070

Sources: Brookes, 2007; Demont and Tollens, 2004; GMO Compass, 2014.
Notes: ?, cultivated but area not known. Zeros indicate no commercial cultivation, but field trials possible. In the early years the area cultivated with Bt maize in the EU has not been well documented.

ise the placing on the market of any GMOs until it is demonstrated that there is no adverse effect on the environment and human health." (ibid).

Since then, the approval process for GMOs in the EU differentiates between risk assessment and risk management. Technical risk assessment is performed by the European Food Safety Authority (EFSA), while risk management, a political decision, involves standing committees, the Commission, and the Council of Ministers (Wesseler and Kalaitzandonakes, 2011). While prior to the Lisbon Treaty the council of ministers was involved in the approval process, since the treaty this has been replaced by the appeal committee. With the adoption of the Lisbon Treaty the approval process has become more strict with respect to deadlines that need to be met.

Further, with the implementation of Directive 2001/18, the procedures for the approval process for GMOs in the EU have been revised. Regulations addressing monitoring, traceability, and labelling followed (Commission of the European Communities 2003a,b,c). Important to notice, is that in the EU a differentiation is made between approval for release into the environment and for placing on the market (Wesseler and Kalaitzandonakes, 2011). While several GMOs have approval for placing on the market, only five events[3] have received approval for cultivation so far: three maize, one potato and three carnation events (GMO-Compass, 2014), while

[3] Genetically engineered crops are produced by introducing DNA coding for beneficial traits into the germplasm of crop varieties. Each time a transformation happened is referred to as an event and plant breeders select those that are of interest. The derived selected transformation event is defined by an abbreviation such as MON810.

Table 3. Labeling requirements for GMOs in the EU.

GM product	Example	Labeling requirement
GM plants, seeds, and food	Maize, maize seed, cotton seed, soybean sprouts, tomato	Yes
Food produced from GMOs	Maize flour, soybean oil, rape seed oil	Yes
Food additive/flavouring produced from GMOs	Highly filtered lecithin extracted from GM soybeans	Yes
GM feed	Maize	Yes
Feed produced from a GMO	corn gluten feed, soybean meal	Yes
Feed additive produced from a GMO	Vitamin B2	Yes
Food from animals fed on GM feed	Eggs, meat, milk	No
Food produced with the help of a GM enzyme	Bakery products produced with the help of amylase	No

Source: modified from Commission of the European Communities (2003a).

only one maize event, MON810, is currently cultivated as a field crop. For events that have not received approval, a zero tolerance level applies, with exceptions under certain conditions for feed products where a 0.1 per cent level applies (Commission of the European Communities, 2011).

Table 3 shows the mandatory labelling requirements for GM food and feed according to Regulation 1830/2003. What is noteworthy in the context of the strategic responses of the food sector are the exemptions for the labelling of enzymes derived from genetically modified bacteria and of animal products derived from animals fed with GM feed, while food products derived from GM crops such as soybean oil (derived from GM soybeans) or sugar (derived from GM sugar beets) must be labelled as such.

An important part of the Directive 2001/18 is the Safeguard Clause under Article 23, which provides member states with the opportunity to ban cultivation in their territory but only under certain conditions: "*Where a Member State, as a result of new or additional information made available since the date of the consent and affecting the environmental risk assessment or reassessment of existing information on the basis of new or additional scientific knowledge, has detailed grounds for considering that a GMO as or in a product which has been properly notified and has received written consent under this Directive constitutes a risk to human health or the environment, that Member State may provisionally restrict or prohibit the use and/or sale of that GMO as or in a product on its territory.*" (Commission of the European Communities, 2001, p. L 106/13).

Several Member States have invoked the safeguard clause to ban the cultivation of MON810, including, among others, France in 2007, Germany in 2009, Greece in 2006, and Hungary in 2005. EFSA has dismissed their arguments as they have failed in providing new scientific reasons for justifying a national ban. The council, who had to decide on the validity of this claim, has not voted in favour, asking the respective Members States to remove the national ban (Wesseler and Kalaitzandonakes, 2011).

In 2003 the European Commission also published recommendations "on guidelines for the development of national strategies and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming", which "should provide a list of general principles and elements for the development of national strategies and best practices for coexistence." (Commission of the European Communities, 2003). As these guidelines are only recommendations member states not necessarily have to implement specific guidelines for the cultivation of GMOs. National coexistence regulations and their impacts on adoption of GM crops are quite diverse. While Spain uses existing regulations to govern the production of GM crops, other countries, such as Bulgaria, use coexistence regulations which effectively ban GM crop production. Many member states have implemented legal rules and regulations governing the cultivation of GMOs that in most cases increase the burden of famers that like to cultivate GM crops and in particular making it more difficult for smaller farms (Beckmann *et al.*, 2011; 2010; 2006; Groeneveld *et al.*, 2013).

The approval process of GMOs for cultivation for several reasons prevented the approval of GMOs for cultivation since 2001. A proposal introduced by Commission President Barroso at the end of 2009 attempted to circumvent the rules of the qualified majority by shifting the authority of cultivation approval to the national level. This proposal was rejected by a number of member states. Legal issues were invoked, including compliance with WTO rules and the Single European Market principle (EESC, 2010). In the same spirit of creating regulatory flexibility, the Commission of the European Communities has prepared another proposal that would allow member states to declare GMO-free areas for different reasons but in line with the principle of the Single European Market. The discussion came to a halt but has gained new momentum since January 2014. By the end of 2014 an agreement between the European Parliament and the EC has been reached on the possibility for "Member States to restrict or prohibit the cultivation of genetically modified organisms (GMOs) in their territory" and is expected to be in place in the first half of 2015 (Keating, 2014).

The year 2011 was another important year affecting the economics of GE crops in the EU. In March of 2011 a new regulation on the authorization procedure for food additives, food enzymes and food flavourings has been introduced that may also effect the use of enzymes produced by genetically engineered bacteria for use in food products. They may need approval ex-post and decision making bodies such as the standing and appeal committees involved may decide similar as they did in the past on other GMOs.

In June 2011 the Council approved a 0.1% tolerance level for unauthorized GM feed imports to the EU and to maintain a zero-tolerance level for unauthorized GM food imports, which has not been considered a change (Wesseler and Kalaitzandonakes, 2011), while the decision by the European Court of Justice in September 2011 has a stronger disruptive effect on food markets. The decision (Europäischer Gerichtshof, 2014) confirms that honey containing pollen of unapproved events cannot be sold in the EU. This practically ends all field trials and hence renders applications for cultivation of GMOs in the EU impossible which require testing in the field under European conditions as part of the approval process as preventing pollen from those trials to appear in honey is almost impossible.

Yet, the EU is not the only region requiring the approval of GMOs. Almost all other countries in one or the other way regulate the cultivation and import of GMOs (Ebata *et al.*, 2013; Falck-Zepeda *et al.*, 2013). As approval processes differ, between countries the approval of GMOs shows asynchronicity, which can result in substantial disruptions in international trade (FAO, 2014). The appearance of the CDC Triffid event in imports of flax seed from Canada, an event that has never been commercialised in Canada; and the appearance of a rice event from research field trials by Bayer in commercial rice fields in the US are two examples. The StarLink case shows that split approvals, approval for use as a feed but not as a food, can cause major market disruptions (Carter and Smith, 2007).

The international trade disruption caused by asynchronicity in the approval process has been become one of the important issues of the Transatlantic Trade and Investment Partnership (TTIP) negotiations between the EU and the US launched in 2013. Substantial welfare gains are in particular expected by reducing regulatory barriers to trade (Felbermayr *et al.*, 2013).

Societal responses in the EU

The introduction of the first products using rDNA technology, including the production of insulin and lactoferrin, met with resistance from different lobby groups (Tramper and Zhu, 2011). Still today, the pharma industry in Europe is concerned about the impact of anti-GMO lobby group activities on pharmaceutical products based on rDNA technology (Lim, 2014; Tramper and Zhu, 2011).

Similarly, from the onset food products derived from GM crops have received strong opposition by anti-GMO lobby groups in Europe, while in the beginning Greenpeace United Kingdom (UK) supported Monsanto's development of a biodegradable credit card from GE bacteria (Nottingham, 2002). Despite the alliance in the case of the credit card with Monsanto, Greenpeace UK stated: "We will continue to campaign against the use of genetically engineered foodstuffs" (Daily News, 1997). Interestingly, the use of enzymes produced by GE bacteria for cheese and bakery products industry has not been a major issue by opponents of the rDNA technology.

Additional problems for the food industry arose with the introduction of the aforementioned FavrSavr tomato (Bruening and Lyons, 2000), and continued with the cultivation of GE food crops such as maize, oilseed rape, and soybeans. Several field trials as well as farmer cultivation of GMOs in the EU have been destroyed. As a result to the opposition on GMOs, the number of field trials in the EU since the late 1990s has been reduced substantially (EuropaBio, 2011). Notifications for environmental releases decreased from 264 in 1997 to 51 in 2012 (JRC, 2014), and farmers are hesitant to cultivate GM crops because of social pressure (Punt, 2013), despite them wanting to cultivate the crop (Skevas *et al.*, 2012; 2010; Venus *et al.*, 2011).

Strategies chosen by food processors and retailers

Strategies chosen by food processors and retailers can be grouped in four major responses: continue with business as usual; adopt a GM-free labelling strategy; adopt a GM-free but not a labelling strategy; or openly not adopt a GM-free strategy (Gaugitsch *et al.*, 2012; Venus *et al.*, 2012). Some retailers have linked their GM-free policy with their sustainability strategy (Vigani and Olper, 2014).

Voluntary GM-free standards by retailers increased in the mid of the first decade in the 21st century. Major German retailers such as Lidl (Schwarz Group), Aldi, ReWe, and the EDEKA group introduced GM-free standards. In Italy, Barilla and COOP introduced

GM-free standards, while in the UK Tesco, Sainsbury, and other UK retailers abolished their GM-free standards in 2013 and 2014. Overall, the degree of GM policies in the EU differs by retailer and by country (Greenpeace 2013, 2005).

Table 4 lists the largest food retailers in the EU selected among the 250 largest retailers in the world (Deloitte, 2014) and whether or not they have a sustainability strategy, an explicit GMO-free policy and if they have a GMO-free policy if this has been linked with the company's sustainability strategy based on their annual report of 2013.

What can be observed is that all 37 retailers had a sustainability strategy in 2013. Fourteen (about 38%) had an explicit GMO-free policy for their home brand and 12 out of the 14 had their GMO-free policy as part of the sustainability strategy in 2013. Those 12 retailers have a share of 32% on the retail revenue. On average, EU food retailers with an explicit GMO-free policy as part of the sustainability strategy included in Table 4 have lower retail revenues, 29,676 Mio. USD in comparison to the overall average of 30,425 Mio. USD, indicating those are the slightly smaller retailers among the top food retailers in Europe.

Food processors also developed GM-free product lines. According to a year-2000 survey by Friends of the Earth "Companies that said that they currently source all their ingredients from GMO-free crops for the food and drink they sell in Europe, include Pepsi Cola, Coca Cola, Heinz, Mars, Danone, Kellogs, Campbell Foods, Cadbury Schweppes and Kraft/Jacobs/Suchard." (Friends of the Earth, 2000). Some companies have mixed strategies such as Friesland-Campina, which sells GM-free labelled dairy products (Landliebe brand) as well as non-labelled ones.

In Germany, several dairy processing companies developed GM-free dairy products such as Bauer and Zott. Meat processors in Germany and other countries developed GM-free meat products too. Barilla, Danone, Nestle, and Unilever all have GM-free labelled product lines. Barilla is one of the larger food processors that have a clear GM-free strategy. According to the company's web-site: "Barilla has therefore decided to play it safe and refrain from the use of genetically modified ingredients, guaranteeing not to use GMO ingredients for all its products. This choice, which stems from our manufacturing strategy, is unrelated to any ideological commitments."

While a number of retailers and food producers entered the GM-free supply of food products, retailers in the UK have deliberately chosen to exit the market. Tesco, among others, has mentioned that the additional costs for GM-free product lines cannot be covered, which is an indication that consumers are unwilling to pay for the additional costs of GM-free products. The costs for GM-free products are an important argument for food processors and retailers is also supported by the market for GM-free products in Germany. Prior to the introduction of modified labelling criteria in 2008 followed by an increase in "GM-free" labeled food products, stricter requirements for GM-free production lines had been requested (transGEN, 2014). Also, McDonalds Germany announced that it will not require its suppliers of chicken meat to feed their chickens GM-free feed (topagrar, 2014). Here, the argument again had been the high costs this sort of policy would incur.

3. Economics of GM-free standards

The recent shift to GM-free food products by several food processors and retailers has implications along the value chain. First, retailers and food processors have to ensure that

Table 4. GMO policy as part of retailer strategy.

Country	No. of food retailers in top 250 retailers	2011 retail revenue (USD million)	Countries present	Sustainability Strategy	GMO-free Policy	GMO-free Policy as part of sustainability strategy	Organic own brand	2011 retail revenue with GMO-fee policy (USD million)	Share of retail revenue GMO-free Policy
Austria	1	12498	8	1	1	1	1	12498	100%
Belgium	3	50232	20	3	0	0	3	0	0%
Finland	2	21660	13	2	2	2	2	21660	100%
France	7	329474	153	7	2	2	7	167798	51%
Germany	8	373263	106	8	3	2	5	104928	28%
Italy	3	36455	4	3	1	1	3	15279	42%
Netherlands	3	60889	19	3	1	1	3	8950	15%
Portugal	1	5737	10	1	1	1	1	5737	100%
Spain	2	30693	3	2	0	0	0	0	0%
Sweden	2	19260	6	2	2	2	2	19260	100%
UK	5	185562	24	5	1	0	4	0	0%
Total	37	1,125,723	n.a.	37	14	12	31	356110	31.63%

Source: company annual reports of 2013, Deloitte, 2014.
Note: n.a. – not applicable due to possible double counting of countries.

ingredients are GM-free; and farmers producing the raw commodity have to comply with the standards. The impact is mainly on livestock farms as arable farms in the EU do not produce GM crops, except for GM maize, which is almost exclusively used as animal feed. Livestock farmers have to ensure that the feeds they purchase are GM-free. This causes a problem mainly for farmers sourcing soybean-based protein feed as soybeans are imported mainly from Argentina and Brazil where more than 90% are GM. As an example, more than 70% of Germany's raw protein is imported, of which more than 76% is derived from soybeans of which more than 96% are imports from non-EU countries cultivating GM soybeans such as Argentina, Brazil, Canada, and the US (Ulmer, 2012).

Some farmer organizations in collaboration with politicians and other stakeholders in the EU also see the trend towards GM-free labelling as a crop production opportunity. Since 2008, an increase in the area allocated to soybean production in the EU can be observed, which mainly took place (according to the most recent data up to 2012) in Eastern Europe. Also, protein substitutes such as oilseed rape in the EU benefit from the demand for GM-free feed. Austria, together with Bavaria, started a Danube Soya Initiative to increase GM-free soybean production in the Danube Region (http://www.donausoja.org/).

However, the GM-free strategy in the EU depends on the availability on non-GM protein sources outside of the EU. In May 2013, a group of retailers signed the Brussels Soy Declaration to signal to Brazilian producers that there is a continuous demand for GM-free soybeans. Pro Terra, the GM-free soybean producers association in Brazil (ABRANGE), announced they would have no problems providing the European market with GM-free soybeans in 2014 (Gyton, 2014).

Nevertheless, GM-free soybeans demand a higher market price. The price premium – about 10% – has been relatively stable between 2008 and 2013 in the EU (Felhoelter, 2013) as well as the Japanese market (Foster, 2010).

For maintaining GM-free standards, contracts between the parties involved are used increasing the cost for maintaining the standard. Extra costs include the development of contracts, monitoring and enforcement of the contracts, as well as higher farm level production costs of the GM-free commodity. These extra costs need to be recovered, and in the end, part of them (not all) has to be shouldered by final consumers.

Higher production standards such as a GM-free strategy involve sunk setup costs including: facilities exclusively processing GM-free commodities, uncertain returns on the market, and the possibility of liability for cases when product standards are not met (Venus et al, 2012).

Economic theory tells us that the incentives for adopting a GM-free food products strategy are higher for smaller retailers and food processors than for larger ones (Venus *et al.*, 2012; Weaver and Wesseler, 2004), primarily, as the latter face relatively higher ex-post liability costs in the case of fraud or mislabelling. Ex-ante irreversible costs with respect to coexistence at farm level and segregation are also important cost factors (Beckmann *et al.*, 2010), which also depend on the specific regulations with respect to coexistence (Beckmann *et al.*, 2014; Beckmann and Wesseler, 2007).

There is the risk for food processors and retailers that not only the specific product, but also other own brands and even the whole chain will be affected. This also discourages the adoption of a higher standard if retailers and food processors are present in several countries and trade between the countries, as well as if the flow of information between the different countries works well (Vigani and Olper, 2014).

But processors and retailers might also adopt different strategies if they are present in several markets. This will be easier for retailers than for food processors as retailers will have it easier to source domestic products to cater differences in consumer preferences. The market size can also increase the adoption of a higher standard if the markets are similar (Vigani and Olper, 2014) such as those in Germany, Austria, and Southern Tyrol with a similar history, cultural background, institutions, and language.

Independent of the countries being present food processors and in particular those producing several products using one input (such as in the dairy sector) will observe an increase in costs not only for the GM-free product line such as milk, but also for other product lines that use the same raw product such as cheese and yoghurt. Higher market prices for the GM-free products have to cover not only the additional cost of GM-free product line, but also the additional costs of the other product lines to avoid overall negative effects on company profits (Venus *et al.*, 2011).

The market power of retailers on the demand side versus food producers, farmers, and food processors on the supply side, may also have an impact on the strategic choices. A higher market power on the demand side encourages vertical product differentiation (von Schlippenbach and Teichmann, 2012), while the same may hold for the supply side depending on its market power, monitoring and enforcement costs, and the size of the vertically differentiated markets (Hamilton and Zilberman, 2006) and also effects whether or not producers will ask for mandatory or voluntary labelling to vertically differentiate food products (Anania and Nistico, 2004). Nevertheless, producers may not have the same interest with respect to the labelling standards being used (Menapace and Moschini, 2014).

A look at German dairy processors shows that a great number of small rather than larger processors indeed use a GM-free labelling strategy (Venus and Wesseler, 2012). Some larger retailers use a GM-free strategy for their own brands, but do not label, such as Lidl and Aldi. This strategy protects the user against complaints from anti-GM food product lobby groups and possible law suits in the event that internal standards are not met, and hence reduces ex-post liability costs. Nevertheless, those companies face the costs of maintaining their internal standards. Another group of retailers and food processors such as METRO or the Müller group do not implement a dedicated GM-free policy for their products. METRO and the Müller group state that they trust the EU's food safety system and consider GM food products as being safe.

Another important factor for food processors and retailers is the pressure environmental lobby groups exert. The two major environmental lobby groups, Greenpeace and Friends of the Earth, are particularly visible in France, Germany, The Netherlands, and the UK (Friends of the Earth, 2013; Greenpeace, 2013; 2005) and have affected company strategies as mentioned earlier. Adopting a GM-free standard increases horizontal product differentiation to the benefits of the retailers (Scatasta *et al.*, 2007) and hence it is not surprising that retailers embrace GM-free labelling strategies, while food processors that shoulder the extra costs are more careful.

4. Discussion and Conclusion

The GM-free standards for own brands in the late 1990s by UK retailers seems mainly to have been a response to pressure from lobby groups. Other retailers in the EU followed in the early 2000's. The UK retailers are also the first ones to abandon the GM-free strategy, and according them, because of costs.

Interestingly, many food processors and retailers have a corporate sustainability strategy with strong commitments for environmental sustainability. The GM-free strategy contradicts the corporate sustainability strategy considering the contribution to sustainability generated by GM crops in general (Bennett *et al.*, 2014; Barrows *et al.*, 2013; Brooks and Barfoot, 2014; Wesseler *et al.*, 2011) and for Europe in particular (Groeneveld *et al.*, 2011; Wesseler *et al.*, 2007; Demont *et al.*, 2004). Surprisingly, this argument has not yet been picked-up by the food industry in Europe as an argument in favour of GM crops.

Environmental lobby groups dismiss the aforementioned benefits; and their views and their power seems to be more important. Their arguments seem to be more convincing for the general public than the arguments of those supporting GMOs, which may become a problem for the food industry. Some food processors and retailers may start to use the environmental argument for leaving a GM-free strategy and generate pressure on those in the food industry that have a pronounced GM-free policy, which is often linked to a sustainability strategy .

A challenge for the EU food industry will be the costs of a GM-free strategy. The experience of the UK retailers shows that those additional costs are difficult to recover. Abandoning a GM-free strategy, or not having one, reduces costs for those retailers and increases their comparative advantage as long as consumers do not differentiate in their purchasing behaviour. While surveys about consumer willingness-to-pay indicate a price premium for GM-free food products, the revealed preferences (Marks *et al.*, 2003) and more differentiated willingness-to-pay studies (e.g. Kikulwe *et al.*, 2011) tell a different story. This will, in particular, affect the GM-free product lines of food processors and retailers' GM-free own brands. The larger the share such products have on overall revenues, the larger the potential exposure of those companies to economic sustainability. But food processors and retailers that are globally active will have better possibilities than those active just in one country. Nevertheless, there is a niche market for GM-free products and this provides opportunities for smaller food processors and retailers.

From an international perspective the EU GM policy increases the costs of its food products and reduces the international competitiveness of its food industry. The asynchronicity in approval processes in combination with a zero tolerance policy for unapproved events generates a disadvantage for the European food industry. But it is not the zero tolerance policy as such, this applies to other countries such as Canada and the US as well, but it is the asynchronicity that generates problems as most new events are developed by companies located in the US and first approved there before receiving approval in the EU.

This asynchronicity provides a strategic advantage for the food industry in those countries where the GM event has been approved over those countries where it has not. The agriculture commodity traders in those countries do not face the threat of rejected cargos due to the presence of unapproved events in shipments, while this is different in the country where the event has not yet been approved. This is an advantage that Walmart, for e.g., with a stronger presence in the US has over, for e.g., Carrefour, Edeka, or Tesco.

Farmers in the EU may receive some short-term gains from the strategic response of the food industry. The demand for GM-free soybeans benefits soybean farmers in the EU, as well as oilseed rape producers, which serves as a substitute for soybean based protein feeds. Also, those who produce for the GM-free market may benefit if the price mark-up overcompensates for the extra costs. This has not yet been observed and it remains a zero sum game for farmers, at least in the dairy sector (Venus and Wesseler, 2012).

Many of the issues discussed in this paper are based on anecdotal evidence. This, to a certain extent, can be justified as the number of observations for the specific cases discussed is small. A systematic empirical investigation is urgently needed to further substantiate the arguments being made on moving into and out of the GM-free standards as the economic implications of strategies chosen are substantial from an economic, social, and environmental perspective. With more than 25 years of observations at hand time series analysis should allow us to empirically test those arguments.

Acknowledgments

An earlier version of this paper was presented at the 3rd Conference of the *Associazione Italiana di Economia Agraria e Applicata* (AIEAA), 25-27 June 2014 at Alghero, Italy.

References

Anania, G. and Nistico, R. (2004). Public Regulation as a Substitute for Trust in Quality Food Markets: What if the Trust Substitute cannot be Fully Trusted? *Journal of Institutional and Theoretical Economics* 160: 681-701.

Barrows, S., Sexton, S., and Zilberman, D. (2014). The impact of agricultural biotechnology on supply and land-use. *Environment and Development Economics* 19(6): 676-703.

Beckmann, V., Soregaroli, C. and Wesseler, J. (2011). Coexistence of genetically modified (GM) and non-modified (non GM) crops: Are the two main property rights regimes equivalent with respect to the coexistence value? In: Carter, C., Moschini, G. and Sheldon, I. (eds), Genetically modified food and global welfare, Bingley, UK: Emerald Group Publishing, 201-224.

Beckmann, V., Soregaroli, C. and Wesseler, J. (2010). Ex-Ante Regulation and Ex-Post Liability under Uncertainty and Irreversibility: Governing the Coexistence of GM Crops. Economics: *The Open-Access, Open-Assessment E-Journal* 4 (2010-9). http://www.economics-ejournal.org/economics/journalarticles/2010-9.

Beckmann, V., Soregaroli, C. and Wesseler, J. (2006). Co-Existence Rules and Regulations in the European Union. *American Journal of Agricultural Economics* 88(5): 1193-1199.

Beckmann, V. and Wesseler, J. (2007). Spatial Dimension of Externalities and the Coase Theorem: Implications for Coexistence of Transgenic Crops. In: W. Heijman (ed.) Regional Externalities, 215-234. Berlin: Springer.

Bennett, A. B., Chi-Ham, C., Barrows, G., Sexton, S. and Zilberman, D. (2013). Agricultural Biotechnology: Economics, Environment, Ethics, and the Future. *Annual Review of Environment and Resources* 3.8: 249-279.

Brookes, G. (2007). The benefits of adopting genetically modified, insect resistant (Bt) maize in the European Union (EU): first results from 1998-2006 plantings. Dorchester, UK: PG Economics Ltd.

Brookes, G. and Barfoot, P. (2014). GM crops: global socio-economic and environmental impacts 1996-2012. Dorchester, UK: PG Economics Ltd.

Bruening, G. and Lyons, J. M. (2000). The case of the FLAVR SAVR tomato. *California Agriculture* 54(4): 6-7.

Carter, C.A. and Smith, A. (2007). Estimating the Market Effect of a Food Scare: the Case of Genetically Modified Starlink Corn. *Review of Economics and Statistics* 89: 522-533.

Commission of the European Communities (2011). COMMISSION REGULATION (EU) No 619/2011 of 24 June 2011 laying down the methods of sampling and analysis for the official control of feed as regards presence of genetically modified material for which an authorisation procedure is pending or the authorisation of which has expired. Official Journal of the European Union L166/9-15.

Commission of the European Communities (2003a). Question and Answers on the regulations of GMOs in the EU. Memo/03/196. Brussels.

Commission of the European Communities (2003b): Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC. Official Journal of the European Union L 268/24-28.

Commission of the European Communities (2003c): Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed. Official Journal of the European Union L 268/1-26.

Commission of the European Communities (2003d): Commission Recommendation of 23 July 2003 on guidelines for the development of national strategies and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming. Official Journal of the European Union L 189/36 -47.

Commission of the European Communities (2001). Directive 2001/18/EU of the European Parliament and of the Council of 12 March 2001on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC. Official Journal of the European Union L 106/1-38.

Daily News (1997). Greenpeace credit card, your biodegradeable friend. <http://www.hurriyetdailynews.com/greenpeace-credit-card-your-biodegradeable-friend.aspx?pageID=438&n=greenpeace-credit-card-your-biodegradeable-friend-1997-05-09>.

Deloitte (2014). Global Powers of Retailing 2014. London, UK: Deloitte Global Services.

Demont, M. and Tollens, E. (2004). First impact of biotechnology in the EU: Bt maize adoption in Spain. *Annals of applied Biology* 145: 197-207.

Demont, M., Wesseler, J., and Tollens, E. (2004). Biodiversity versus transgenic sugar beets – the one Euro question. *European Review of Agricultural Economics* 31(1): 1-18.

Ebata, A., Punt, M., and Wesseler, J. (2013). The Approval Process of GMOs: The Japanese Case. *AgBioForum* 16(2): 140-160.

EESC (2010). Opinion of the European Economic and Social Committee on the Proposal for a Regulation of the European Parliament and of the Council amending Directive 2001/18/EC as regards the possibility for the Member States to restrict or prohibit the cultivation of GMOs in their territory COM(2010) 375 final – 2010/0208 (COD). NAT/480 - CESE 1623/2010 - 2010/0208 (COD). Available at: http://www.eesc.europa.eu/?i=portal.en.events-and-activities-467th-plenary-session-documents.

EU Environmental Council, 1999. 2194th Council meeting, Luxembourg, 24/25 June 1999. C/99/203/. Avialable at: http://europa.eu/rapid/pressReleasesAction.do?reference=PRES/99/203&format=HTML&aged=0&lg=fi&guiLanguage=en.

EuropaBio (2011). Approvals of GMOs in the European Union. EuropaBio, Brussels.
Europäischer Gerichtshof (2014). Urteil des Gerichtshofes „Genetisch veränderte Lebensmittel – Verordnung (EG) Nr. 1829/2003 – Art. 2 bis 4 und 12 – Richtlinie 2001/18/EG – Art. 2 – Richtlinie 2000/13/EG – Art. 6 – Verordnung (EG) Nr. 178/2002 – Art. 2 – Imkereiprodukte – Eintrag von Pollen aus genetisch veränderten Pflanzen – Folgen – Inverkehrbringen – Begriffe ‚Organismus' und ‚Lebensmittel, die Zutaten enthalten, die aus genetisch veränderten Organismen hergestellt werden'", September 6, 2011.
Falck-Zepeda, J., Wesseler, J. and Smyth, S. (2013). The current status of the debate on socio-economic regulatory assessments: positions and policies in Canada, the USA, the EU and developing countries. *World Review of Science & Technology and Sustainable Development* 10(4): 203-227.
FAO (2014). The results of the FAO survey on low levels of genetically modified (GM) crops in international food and feed trade. Rome: FAO.
Felbermayr, G., Larch, M., Flach, L., Yalcin, E., and Benz, S. (2013). Dimensionen und Auswirkungen eines Freihandelsabkommens zwischen der EU und den USA. München: ifo Institut.
Felhölter, U. (2013). Feed Retailer. Personal communication.
Foster, M. (2010). Evidence of price premiums for non-GM grains in world markets. ABARE.GOV.AU 10.04 Conference Paper. Australian Bureau of Agricultural and Resource Economics.
Friends of the Earth Europe (2013): Maize 1507: toxic and inadequately tested. Why GM maize 1507 should be banned. Brussels, Belgium.
Friends of the Earth Europe (2000). European food manufacturers shun GMOs but consumers urged to keep up pressure. Press Release. Available at: http://www.foe.co.uk/cymru/english/press_releases/european_food_manufacturers.html.
Gaugitsch, H. and Heissenberger, A. (2012) Comparison of regulatory frameworks of Austria, Germany, France, and South Tyrol for GM free labelling of food products. Österreich: Umweltbundesamt.
GMO Compass (2014). GMO Database. <http://www.gmo-compass.org/eng/gmo/db/>.
Graff, D.G., Hochman, G. and Zilberman, D. (2009). The Political Economy of Agricultural Biotechnology Policies. *AgBioForum* 12(1): 34-46.
Greenpeace (2013). Essen ohne Gentechnik. Hamburg: Greenpeace e.V.
Greenpeace (2005) EU Markets – No Market for GM Labelled Food in Europe. The Netherlands: Primavera Print.
Groeneveld, R., Ansink, E., van de Wiel, C. and Wesseler, J. (2011). Benefits and costs of biologically contained GM tomatoes and eggplants in Italy and Spain. *Sustainability* 3: 1265-1281.
Groeneveld, R., Wesseler, J. and Berentsen, P. (2013). Dominos in the dairy: An analysis of transgenic maize in Dutch dairy farming. *Ecological Economics* 86(2): 107-116.
Gyton, G. (2014) Claims over supply of GMO-free soy refuted. Global Meat, 25 February, 2014.
Hamilton, S. and Zilberman, D. (2006). Green markets, eco-certification, and equilibrium fraud. *Journal of Environmental Economics and Management* 52: 627-644.
Herring, R. (2008). Opposition to transgenic technologies: ideology, interests and collective action frames. *Nature Genetics* 9: 458-463.

JRC (2014). Deliberate Release and Placing on the EU Market of GMOs – GMO Register. Available at: http://gmoinfo.jrc.ec.europa.eu/overview/.

Katz, S. and Voigt, M. (1986). Bread and Beer. *Expedition* 28(2): 23-34.

Keating, D. (2014) Deal reached to allow national bans on GOM crops. EuropeanVoice 04.12.2014. Available at: http://www.europeanvoice.com/article/deal-reached-on-national-bans-of-gm-crops/.

Kikulwe, E., Birol, E., Wesseler, J., Falck-Zepeda, J. (2011): A Latent Class Approach to Investigating Developing Country Consumers' Demand for Genetically Modified Staple Food Crops: The Case of GM Banana in Uganda. *Agriculture Economics* 42: 547-560.

Lim, X.Z. (2014). Will European Opposition to GM Foods Slow Biomedical Advances? Genetic Literacy Project. <http://www.geneticliteracyproject.org/2014/04/24/scare-creep-will-european-opposition-to-gm-foods-slow-biomedical-advances/>.

Lubov, S. (1999). Good Intentions. Forbes. <http://www.forbes.com/forbes/1999/0208/6303062a.html>.

Marks, L.A., Kalaitzandonakes, N.G., Vickner, S.S. (2003). Consumer Purchasing Behaviour Towards GM Foods in the Netherlands. In: Evenson, R.E. and Santaniello, V. (eds.), Consumer Acceptance of Genetically Modified Foods, Wallingford, UK: CABI, 23-40.

Menapace, L. and Moschini, G. (2014). Strength Protection for Geographical Indicators: Promotion Incentives and Welfare Effects. *American Journal of Agricultural Economics* 96(4): 1030-1048.

Nottingham, S. (2002). Genescapes: The Ecology of Genetic Engineering. London, UK: Zed Books.

Punt, M. (2013). The costs of coexistence on farms in Germany. Paper presented at the 17th International Consortium on Applied Bioeconomy Research (ICABR) Conference Innovation and Policy for the Bioeconomy, Ravello, Italy, June 18 – 21, 2013.

Qaim, M. (2009). The Economics of genetically Modified Crops. *Annual Review of Environment and Resources* 1: 3.1–3.29.

Rabesandratana, T. (2014). Cultivation of Unpopular GM Maize in Europe Hangs in the Balance. *ScienceInsider* 11th February, 2014.

Scatasta, S., Wesseler, J. and Hobbs, J. (2007). Differentiating the consumer benefits from labelling of GM food products. *Agriculture Economics* 37(2-3): 237-242.

Skevas, T., Fevereiro, P., and Wesseler, J. (2010). Coexistence Regulations & Agriculture Production: A Case Study of Five Bt Maize Producers in Portugal. *Ecological Economics* 69(12): 2402-2408.

Skevas, T., Kikulwe, E., Papadopoulou, H., Skevas, I. and Wesseler, J. (2012). Do European Union Farmers Reject Genetically Modified Maize? Farmer Preferences for Genetically Modified Maize in Greece. *AgBioForum* 15(3): 242-256.

Smart, R., Blum, M., and Wesseler, J. (2014). EU member states'voting behavior on GE crop approvals. Paper presented at the 18th International Consortium on Applied Bioeconomy Research (ICABR) Conference Bioeconomy and Development, Nairobi, Kenya, June 18-20, 2014.

Smart, R., Blum, M. and Wesseler, J. (2012). Approval Processes: comparing Canada, the EU, South Africa, and the US. Paper presented at the 16th International Consortium on Applied Bioeconomy Research (ICABR) Conference The Political Economy of the Bioeconomy: Biotechnology and Biofuel, Ravello, Italy, June 24-27, 2012.

Smyth, S., Phillips, P.W.B. and Castle, D. (eds.) (2014). Handbook on Agriculture, Biotechnology and Development. Cheltenham, UK: Edward Elgar.

Stevens, A.J. (2004). The Enactment of Bayh – Dole. *Journal of Technology Transfer* 29: 93-99.

topagrar (2014). McDonald´s erlaubt wieder GVO-Futter für Hähnchen. <http://www.topagrar.com/news/Home-top-News-McDonald-s-erlaubt-wieder-GVO-Futter-fuer-Haehnchen-1436694.html>.

Tramper, J. and Zhu, Y. (2011). Modern Biotechnology. Wageningen, NL: Wageningen Academic Publishers.

transGEN (2014). Ohne Gentechnik- wieviel Gentechnik ist erlaubt? <http://www.transgen.de/recht/kennzeichnung/280.doku.html>

Ulmer, H. (2012). Bayerische Eiweiß – Strategie GVO – freier und ökologischer Anbau in Bayern und europäischen Donau – Regionen. München: Landesvereinigung für den Ökologischen Landbau in Bayern e.V.

Venus, T. and Wesseler, J. (2012). Bereits doppelt so viel „ohne Gentechnik"- Milch als Biomilch in Deutschland: Welche Bedeutung hat GVO-freie Milch für unsere Milchwirtschaft? *Deutsche Molkerei Zeitung* 133(2): 24-26.

Venus, T., Kalaitzandonakes, N. and Wesseler, J. (2012). Ist das Angebot von Nahrungsmitteln "Ohne Gentechnik" wirtschaftlich Nachhaltig? *Quarterly Journal of Economic Research* 81(4): 93-110.

Venus, T., Casadamon, R., Soregaroli, C. and Wesseler, J. (2011) Comparison of Bt and Non-Bt maize cultivation gross margin: a case study of maize producers from Italy, Spain and Germany. FuturAgra, Rome.

Vigani, M. and Olper, A. (2014). GM-free private standards, public regulation of GM products and mass media. *Environment and Development Economics* 19(6): 743-768.

Von Schlippenbach, V. and Teichmann, I. (2012). The Strategic Use of Private Quality Standards in Food Supply Chains. *American Journal of Agricultural Economics* 94(5): 1189-1201.

Weaver, R.D. and Wesseler, J. (2004). Food system value chains: implications for agricultural policy. In: Van Huylenbroeck, G., Verbeke, W. and Lauwers, L. (eds.), Role of Institutions in Rural Policies and Agricultural Markets, Amsterdam: Elsevier, 213-223.

Wesseler, J. and Kalaitzandonakes, N. (2011). Present and Future EU GMO policy. In Oskam, A., Meesters, G. and Silvis, H. (eds.), EU Policy for Agriculture, Food and Rural Areas, Second Edition, Wageningen, NL: Wageningen Academic Publishers, 23-323 – 23-332.

Wesseler, J., Scatasta, S. and Fall, E.H. (2011). Environmental Benefits and Costs of GM Crops. In: Carter, C., Moschini, G. and Sheldon, I. (eds), Genetically modified food and global welfare, Bingley, UK: Emerald Group Publishing, 173-199.

Wesseler, J., Scatasta, S. and Nillesen, E. (2007). The Maximum Incremental Social Tolerable Irreversible Costs (MISTICs) and other Benefits and Costs of Introducing Transgenic Maize in the EU-15. *Pedobiologia* 51(3): 261-269.

Wesseler, J. and Zilberman, D. (2014). The Economic Power of the Golden Rice Opposition. Environment and Development Economics. doi:10.1017/S1355770X1300065X.