Review Article

Biotechnologies and agrifood strategies: opportunities, threats and economic implications

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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
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 ontology” and hence the term is a political construct (Herring, 2008).
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>Development of rDNA technology</td>
</tr>
<tr>
<td>1980</td>
<td>Bayh-Dole act, providing intellectual property right to organisation and individuals from inventions with public funding in the US.</td>
</tr>
<tr>
<td>1982</td>
<td>Vaccine against swine diarrhoea and production of human insulin (US) by means of rDNA technology</td>
</tr>
<tr>
<td>1986</td>
<td>First cases of bovine spongiform encephalopathy (BSE) in cattle in the UK reported starting the &quot;mad-cow-disease&quot; crisis in the EU.</td>
</tr>
<tr>
<td>1986</td>
<td>OECD publication on &quot;Recombinant DNA safety considerations&quot;, so called &quot;Blue Book&quot;, setting international standards for safety assessments.</td>
</tr>
<tr>
<td>1990</td>
<td>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</td>
</tr>
<tr>
<td>1991</td>
<td>Report about HIV contaminated blood samples knowingly be distributed in France published and together with the handling of the &quot;Mad Cow Disease&quot; undermining public trust in regulatory health safety systems in the EU.</td>
</tr>
<tr>
<td>1995</td>
<td>Flavr Savr tomato introduced by Calgene (US) but withdrawn in 1999.</td>
</tr>
<tr>
<td>1996</td>
<td>Dolly, a cloned sheep was born.</td>
</tr>
<tr>
<td>1998</td>
<td>First GE crop approved for cultivation in the EU (MON810)</td>
</tr>
<tr>
<td>1999</td>
<td>Environmental Council of the EU calls for a temporary ban of approvals of GMOs (&quot;quasi moratorium&quot;) in July 1999.</td>
</tr>
<tr>
<td>1999</td>
<td>Apad Pusztai claims negative effects of GM technology on the biology of rats in August 1999.</td>
</tr>
<tr>
<td>2000</td>
<td>StarLink Case: traces of StarLink corn, not approved for human consumption were found in food products (taco shells) in the US.</td>
</tr>
<tr>
<td>2000</td>
<td>Friends of the Earth Europe launches an EU wide campaign &quot;calling for a halt to the GMO pollution of food and the environment&quot;.</td>
</tr>
<tr>
<td>2001</td>
<td>EU Directive 2001/18 on the deliberate release of GMOs into the environment published. Includes the safeguard clause.</td>
</tr>
<tr>
<td>2002</td>
<td>European Food Safety Authority established. Tasks among others the environmental and food safety assessment of genetically modified organisms (GMOs).</td>
</tr>
<tr>
<td>2003</td>
<td>Regulation 1830/2003 on traceability and labelling of GMOs published. Introduces the 0.9% threshold level for labelling.</td>
</tr>
<tr>
<td>2003</td>
<td>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.</td>
</tr>
<tr>
<td>2009</td>
<td>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.</td>
</tr>
<tr>
<td>2009</td>
<td>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.</td>
</tr>
<tr>
<td>2011</td>
<td>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.</td>
</tr>
<tr>
<td>2011</td>
<td>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.</td>
</tr>
<tr>
<td>2012</td>
<td>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.</td>
</tr>
<tr>
<td>2013</td>
<td>TTIP negotiations launched. GMO approval policy in the two regions important part of the agenda.</td>
</tr>
</tbody>
</table>
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).

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.
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Biotechnologies and agrifood strategies are 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 approval for placing on the market (Wesseler and Kalaitzandonakes, 2011). While several GMOs have approval for placing on the market, only five events have received approval for release into the environment and are referred to as an event (GMO-Compass, 2014), while plant breeders select those that are of interest. The derived selected transformation event is defined by an abbreviation such as MON331. 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.

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Spain</th>
<th>France</th>
<th>Czech Republic</th>
<th>Portugal</th>
<th>Germany</th>
<th>Slovakia</th>
<th>Romania</th>
<th>Poland</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>22,000</td>
<td>2,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24,000</td>
</tr>
<tr>
<td>1999</td>
<td>30,000</td>
<td>&lt;2,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&gt;31,000</td>
</tr>
<tr>
<td>2000</td>
<td>20,000</td>
<td>&lt;500</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&gt;20,000</td>
</tr>
<tr>
<td>2001</td>
<td>25,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&gt;25,000</td>
</tr>
<tr>
<td>2002</td>
<td>25,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>&gt;25,000</td>
</tr>
<tr>
<td>2003</td>
<td>58,000</td>
<td>492</td>
<td>150</td>
<td>750</td>
<td>342</td>
<td>0</td>
<td>?</td>
<td>0</td>
<td>&gt;58,000</td>
</tr>
<tr>
<td>2004</td>
<td>53,225</td>
<td>5,000</td>
<td>1,290</td>
<td>1,250</td>
<td>947</td>
<td>30</td>
<td>350</td>
<td>100</td>
<td>&gt;25,000</td>
</tr>
<tr>
<td>2005</td>
<td>53,667</td>
<td>21,147</td>
<td>5,000</td>
<td>4,500</td>
<td>2,685</td>
<td>900</td>
<td>7146</td>
<td>320</td>
<td>&gt;25,000</td>
</tr>
<tr>
<td>2006</td>
<td>75,148</td>
<td>0</td>
<td>8,380</td>
<td>4,851</td>
<td>3,171</td>
<td>1,900</td>
<td>3,344</td>
<td>3,000</td>
<td>&gt;58,000</td>
</tr>
<tr>
<td>2007</td>
<td>79,269</td>
<td>0</td>
<td>6,480</td>
<td>5,094</td>
<td>0</td>
<td>875</td>
<td>823</td>
<td>3,000</td>
<td>&gt;25,000</td>
</tr>
<tr>
<td>2008</td>
<td>76,057</td>
<td>0</td>
<td>4686</td>
<td>5500</td>
<td>0</td>
<td>1740</td>
<td>588</td>
<td>3500</td>
<td>&gt;58,000</td>
</tr>
<tr>
<td>2009</td>
<td>76,575</td>
<td>0</td>
<td>5090</td>
<td>7723</td>
<td>0</td>
<td>761</td>
<td>217</td>
<td>3000</td>
<td>&gt;58,000</td>
</tr>
<tr>
<td>2010</td>
<td>76,755</td>
<td>0</td>
<td>3080</td>
<td>9278</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4000</td>
<td>&gt;58,000</td>
</tr>
<tr>
<td>2011</td>
<td>97,325</td>
<td>0</td>
<td>9278</td>
<td>7723</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4000</td>
<td>&gt;58,000</td>
</tr>
<tr>
<td>2012</td>
<td>116,306</td>
<td>0</td>
<td>31,000</td>
<td>115,386</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4000</td>
<td>&gt;58,000</td>
</tr>
</tbody>
</table>

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.

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Genetically engineered crops are produced by introducing DNA coding for beneficial traits into the germplasm of crop varieties. Each time a transformation happens it 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 MON331.
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 geneti-
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cally 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 produc-
tion of GM crops, other countries, such as Bulgaria, use coexistence regulations which effect-
tively ban GM crop production. Many member states have implemented legal rules and reg-
ulations 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 Pres-
ident Barroso at the end of 2009 attempted to circumvent the rules of the qualified major-
ity 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 discus-
sion 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 modi-
fied 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 com-
mittees 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 dis-
ruptive 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 impos-
sible 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 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.

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

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.

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