Promotors:	Prof. dr. ir. Guido Van Huylenbroeck (UGent)
	Prof. dr. ir. Joost Dessein (ILVO, UGent)
Members of the jury:	Prof. dr. ir. Dirk Reheul (UGent, Chairman)
	Prof. dr. Godelieve Gheysen (UGent)
	Prof. dr. Johan Braeckman (UGent)
	Prof. dr. John Grin (Universiteit Amsterdam)
	Prof. dr. ir. Peter-Paul Verbeek (Universiteit Twente)
Dean:	Prof. dr. ir. Marc Van Meirvenne
Rector:	Prof. dr. Anne De Paepe

GM CROPS IN THE EU AS A WICKED PROBLEM. ON TECHNOLOGY, MORALITY AND A POLARISED DEBATE

Linde Inghelbrecht

Thesis submitted in fulfillment of the requirements for the degree of
Doctor (PhD) in Applied Biological Sciences

Dutch translation of the title:

Ggo-gewassen in de EU, een hardnekkig probleem.
Over technologie, moraliteit en een gepolariseerd debat.

Please refer to this work as follows:

Inghelbrecht, L. (2016). GM crops in the EU as a wicked problem. On technology, morality and a polarised debate. PhD-thesis, Ghent University, Ghent, Belgium.

This work was financed with a pre-doctoral fellowship by the FWO (Research Foundation - Flanders), and performed in close collaboration with the Social Sciences Unit at the Institute for Agricultural and Fisheries Research (ILVO).

ISBN-number 978-90-5989-877-6

Cover photo: Egon Gade Photography (http://www.egongadeartwork.com/).
The DNA strings in the background illustrate the link with genetic modification. The green colour emphasises agricultural applications. The empty seat in front represents the high level of debate involved and the absence of real authority for any particular actor group in framing 'the problem' with GM crops in the EU – referring to the concept of wicked problems.

ACKNOWLEDGEMENT

"Thinking takes time. It requires time to 'waste' in the act of imagination, in the pursuit of curiosity, in the quest to look at the world from multiple perspectives." (unknown)

Deze oefening was enorm divers, bijna het maken van een kleine wereldreis 'aan gedachten'. Daarom was het zo een fijne uitdaging. Dit werk bracht me ook een nieuw perspectief. Verwondering! Met hoogtes en laagtes weliswaar, maar ik heb dit doctoraat met plezier geschreven.

Tijdens dit traject hebben vele mensen rondom mij me gesteund en ondersteund, op verscheidene vlakken, zowel professioneel als persoonlijk en ik wil jullie bij deze heel graag bedanken voor de weg die we samen hebben afgelegd! Mede dankzij jullie steun is dit werk er nu. Dank jullie wel daarvoor!

Allereerst zou ik graag mijn promotoren Joost Dessein en Guido Van Huylenbroeck willen bedanken. Joost, jij gaf me vertrouwen in mezelf en in mijn kunnen. Ik haalde ook veel motivatie uit onze gesprekken en vond het heel fijn hoe je telkens kritisch mee reflecteerde. Dankjewel voor deze leuke samenwerking! Guido, ook jou wil ik oprecht bedanken, omdat je net altijd die vragen wist te stellen die het werk nog ontbrak. Beide promoteren, bedankt voor de kans en de vrijheid om mijn eigen weg hierin te gaan! Beste juryleden, ook jullie wil ik bedanken, voor jullie tijd en inzet om mee na te denken over dit werk. Jullie reflecties waren inspirerend.

Gert Goeminne, ook jou wil ik specifiek bedanken. Wat begon met urenlange brainstorms en 'ja maar' discussies over mediatietheorie, is uiteindelijk toch mooi samengekomen. Voor mij was deze samenwerking ontzettend inspirerend en ik ben je ook dankbaar dat je, ondanks verkenning van een nieuwe horizon, me bent blijven bijstaan. Frank Nevens, ook wij hebben samen een interessant traject afgelegd. Want jij maakte het MLP minder mysterieus! Begrijpelijker. Dankjewel om samen deze uitdaging aan te gaan. Michiel De Krom en Thomas Block, dank jullie wel, om af en toe mee op deze trein te springen en me analytisch uit te dagen.

Fleur Marchand, Ludwig Lauwers en Erwin Wauters, dankjewel. Mijn begeleidingscommissies waren altijd aanmoedigend en ondersteunend. Jullie hebben me altijd vertrouwen gegeven. Ludwig, jou wil ik ook in het bijzonder bedanken omdat je mijn plekje op L&M gevrijwaard hebt! Ondanks een bijna overbevolking van onze bureaus, tot aan de verhuis, wist je hoe graag ik op L&M werk en dat heb je altijd ondersteund. Heel erg bedankt daarvoor. Ook alle L&M collega's,

jullie wil ik bedanken. Onze werkplek is echt heel fijn. Er wordt geïnvesteerd in verbinding met elkaar, door alle (sfeer)team momenten, 'flok'-momenten, afterwork uitjes en pingpong momenten buiten onze uren. Dat maakt L&M een leuke werkplek, die me zin gaf om te gaan werken. Lieve Charlotte Prové, jij bent altijd een toeverlaat geweest. Je bent zo een toffe collega, waar ik veel van geleerd heb en me op mijn gemak bij voel. Dankjewel om er te zijn voor mij! Lieve Kirsten Vanderplanken en Marlinde Koopmans, die kop-vol-koffie momenten op ons bureau waren telkens uniek. Ik heb me ook ondersteund gevoeld door jullie, waarvoor dank! En Kirsten, 'in mijn kotje', tijdens mijn retraite in de laatste sprint, ben jij er echt voor mij geweest, dankjewel.

Lieve schat, ook jou wil ik in het bijzonder bedanken, voor de thuis die we samen hebben. Het was niet altijd makkelijk voor jou als ik thuiskwam met mijn hoofd 'vol vraagstukken'. Maar je bracht me telkens weer naar mezelf, in balans en je gaf me een onvoorwaardelijke steun en vertrouwen waar ik onnoemelijk veel aan gehad heb.

Mama, ook jij verdient een apart plekje in dit dankwoord. Je ondersteunt me telkens opnieuw. Dankjewel voor de plaats die je inneemt in mijn leven. Ook papa, broer, mémé, Christine, dank jullie wel om mee te juichen langs de zijlijn! Het deed deugd. Mijn lieve opa, jou vertel ik alles in stilte. Maar ik mis het ontzettend om de dingen zoals vroeger met jou te kunnen delen. Wat had ik graag gehad dat je op dit moment aanwezig was geweest!

Ook lieve Nicole en Heidi, telkens weer nemen jullie een bijzonder plaatsje in. Jullie helpen me de ontbrekende puzzelstukjes te vinden en ik heb ook veel vertrouwen getankt uit jullie onvoorwaardelijk geloof in mij. Enorm bedankt, dat jullie deel uitmaken van mijn leven! En lieve Nicole, die laatste eindsprint hebben we zij-aan-zij gemaakt. Dankjewel!

Lieve Anna, ook jij bracht me aan deze finishlijn! Onze gesprekken zijn zo waardevol voor mij. Ze leren me mezelf kennen en dat had ik nodig om dit doctoraat tot een goed einde te kunnen brengen. Onze gesprekken voelen aan als thuiskomen. Ze geven me opnieuw adem, ruimte, kracht en inspiratie om met die intensiteit in het leven te staan zoals ik wil!

Lieve Anouska, ook jij bent heel aanwezig geweest in dit traject. Van op de schoolbanken tot nu, sta je er. Naast mij, dankjewel daarvoor! Ik kijk alvast uit naar nog heel veel zotte en plezante momenten die gaan komen!

Voor dit alles, en veel meer, wil ik jullie graag bedanken!
Linde

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BSE	Mad cow disease
CRS	Certified Socially Responsible
DNA	Deoxyribonucleic acid
EFSA	European Food Safety Authority
EU	European Union
GM	Genetically modified
GMI	Genetically modified ingredient(s)
GMO	Genetically modified organism
LLP	Low level presence
MLP	Multi-level perspective
NGO	Non-governmental organisation
R&D	Research and development
RQ	Research question
SA	Structuring arena
WTO	World Trade Organisation

Cultures of non-knowledge

The cultures of non-knowledge refer to competing evaluations of what is known and not known between social actors. They express the view that sciences themselves are not homogeneous and uniform in terms of how they generate, define, communicate and investigate non-knowledge. Instead various epistemic cultures exist which differ not only in how they produce knowledge, but also in how they deal with non-knowledge. Non-knowledge is therefore not a homogeneous entity, but both 'multifaceted' and 'socially negotiated' (Böschen et al. 2010).

Depoliticisation

In the process of depoliticisation, decision-making is no longer a question of political position, but of expert knowledge. It is a way to shortcut a democratic struggle over possible courses of action that go beyond the existing status-quo. Instead, a democratic struggle is replaced with technocratic decision-making or a focus on market forces. So, depoliticisation implies making the political invisible for political purposes. These processes are therefore an important tactic or strategy for framing the scope of conflict, as they separate legitimate from illegitimate actors or practices (Maeseele et al. 2013).

Framing struggles: credibility, empirical fit, centrality and experiential commensurability

In framing struggles, the success of specific frames depends on positive scores for the following four aspects (copied from Geels and Verhees 2011):

(1) Actor credibility: the status or perceived expertise of the social groups advocating particular frames.
(2) Empirical fit: the perceived correspondence between the frame and real-world events (the more 'evidence' a frame can claim, the higher its empirical fit).
(3) Centrality: the perceived importance of the topic or debate to particular audiences relative to other topics or debates.
(4) Experiential commensurability: the resonance between the frame and the everyday experiences of audiences (if frames are very abstract and have little bearing on people's daily life, experiential commensurability is low).

Ethics

Ethics is an area of study, which discusses how to act, and how to live: it deals with what is morally right or wrong, or good and bad behaviour. We also perform ethics when we put forward moral routines for discussion. Ethics is therefore 'active' or 'hot' morality; morality is 'passive' or 'cold' ethics (Swierstra and Rip 2007; Verbeek 2011).

Logical and topical truth

The logical truth concerns the truth of the scientific answer ('who is right?'). It focuses on whether the correct deduction rules were applied, or it discusses the experimental set-up for an analysis, for example. The logical truth is consequently a matter of concern for the sciences.
The topical truth is the truth of the scientific question being asked ('what is the issue at stake?'). Rather than questioning the validity of the scientific answers, the topical truth questions the scientific question itself. Topical truth consequently points to the idea that behind the logical truth of any scientific answer, there lies a different kind of truth: the truth of the scientific question, and this is not only a scientific matter (Goeminne 2011, 2013).

Morality

Morality is a social code of good conduct; a collection of ideas of right and wrong behaviour that is normalised within society. Morals exist mainly as self-evident routines. We mainly become aware of them when people disobey them, when new moral dilemmas arise, or when they are no longer able to provide satisfactory responses to new problems (Swierstra and Rip 2007).

Moral significance of technology

In mediation theory, technologies-in-use actively influence individuals' perceptions and actions. In doing so, technologies have an influence on perceptions of what is 'normal', 'right' or 'wrong', and can thus partially answer the (ethical) question of 'how to act'. Therefore, technologies are said to have moral significance (Verbeek 2011).

Niche-type of environment

Niches are spaces that allow for a co-evolution of technology, user practices, and regulatory structures. Often, niches represent alternative sociotechnical configurations which have not yet achieved a strong degree of institutionalisation, but which have the potential to form future (radically different) regime structures (Fuenfschilling and Truffer 2014; Schot and Geels 2008).

Paradigm

A paradigm is a view on how things work in the world. It is a set of assumptions, values, and practices that constitutes a way of viewing reality within a community that shares them. They are actors' operative models used in conceptualising and judging problems, or judging possible solutions for dealing with key problems (Burns and Carson 2002).

Paradigm-driven view on scientific knowledge

In a paradigm-driven view on scientific knowledge, scientific 'facts' are not just ideal representations or mirrors of the world. Scientific facts are actively framed presentations of the world, because of socially structured internalities (things taken into account) and externalities (things not taken into account) in the scientific set-up (Goeminne 2011, 2013).

Path-dependency

The concept of path-dependence assumes that actors' behaviour and technology development occur relatively deterministically. It refers to the persistence of existing institutions and practices, which naturally repeat themselves. The focus in path-dependence is therefore on self-reinforcing mechanisms (Garud et al 2010; Thrane et al. 2010).

Script and user logic

When designing a new technology with attention for technological mediation, the script logic focuses on which norms and values are embodied ("materialised") and which ones are excluded from the design.
The user logic focuses on how the technology is, or can be, interpreted and appropriated by its users. It focuses on possible interpretations and appropriations by users, and anticipates the various possible use contexts for the new technology-in-design (Verbeek 2011).

Second-order learning

In second-order learning, it is not only the actor's perspective on the solution and strategies that is modified, but also their goals, vested interests, standards and values (Poppe et al. 2009).

Sociotechnical practice around GM crops

A sociotechnical practice around GM crops is a network of actors and artefacts that operationalise the production, dissemination and use of a GM crop (within the context of the overall EU agricultural regime in this thesis).

Technological mediation

In technological mediation, it is said that technologies direct the actions and experiences of human beings. This directedness is not the same as human intentions, because technologies cannot deliberately do something. Their intentionality can only be found in particular affordances for action or in particular representations of the world. Therefore, rather than being mere instruments to realise human goals, technologies-in-use actively help to shape human interpretation and human action by shaping the relationship between humans and reality.
Verbeek differentiates between a practical and a hermeneutical dimension of mediation. Hermeneutic mediation refers to how technologies affect our perception of the world. Pragmatic mediation refers to the way in which technologies influence how an individual acts and lives (Verbeek 2006b, 2011; Waelbers 2009).

CHAPTER 1.
INTRODUCTION:
THE LOCK-IN FOR GM CROPS WITHIN EU AGRICULTURE.

… Each another perspective and direction.

CHAPTER 1.
INTRODUCTION:
THE LOCK-IN FOR GM CROPS WITHIN EU AGRICULTURE.

"We lose something wonderful when it becomes more important to us to be the one who knows than to be the one who's open to the everyday wonders around us. Those who think they know it all have no way of finding out they don't. Fortunately, our sense of curiosity and wonder can be rekindled and refreshed. To become a beginner again." (Leo Buscaglia)

1.1 The EU situation for GM crops: an interesting case-study

Genetically modified crops are plants whose genetic material (DNA) has been modified using genetic engineering techniques. These techniques allow the artificial introduction of new traits within a plant that do not occur naturally in a species through mating and/or natural recombination. Food and feed which contain or consist of such genetically modified (GM) crops, or are produced from them, are called GM food or feed (Directive 2001/18/EC; Regulation 1946/2003). However, the legislative definition and interpretation of a GM crop in the European Union (EU) is the topic of extensive political and social discussion at the moment (e.g. COGEM 2009; NTB Platform 2013; VIB 2014; VILT 2016). This is because it is unclear whether or not this definition implies that the new trait obtained through genetic engineering *does not* occur naturally, or *does not and cannot* occur naturally in a species. In the latter case, only the insertion of genes from another organism (transgenesis) results in a GM crop, whereas the artificial insertion of genes from naturally crossing species (cisgenesis) does not, because those genetic adaptations could, in theory, also occur naturally (European Commission 2016a).

Most existing (transgenic) GM crops have been developed for resistance or tolerance to biotic stresses (such as pests), and abiotic or environmental stresses (such as drought or temperature extremes). Besides these first-generation GM crops, with improved agronomic traits, second-generation GM crops have product-quality characteristics which have more direct consumer benefits. These second-generation characteristics include enhanced nutritional values (such as healthier oils or vitamin-enriched products), or better processing characteristics for particular purposes (such as starch modification or improved sugar content). Third generation GM crops contain pharmaceutical compounds (such as vaccines or therapeutic proteins), or traits that are useful for industrial purposes (such as biofuels, enzymes or degradable plastics) (Benkeblia 2011; Stewart and McLean 2005).

Proponents of GM crops argue that the technology can make an essential contribution to increasing agricultural production, food quality, improving livelihoods, and enhancing food quality in both the developed and developing world. In contrast, critics argue that agricultural biotechnology undermines food security, reduces biodiversity and creates an increasing dependence on multinationals for food production (Dibden et al. 2013).

The ongoing debate about GM crops in the EU is highly polarised and perhaps even thought of as an overworked subject. That is why we will start this dissertation by discussing some inconsistencies and occurrences that illustrate the complexity associated with GM crop applications within EU agriculture. This will demonstrate why this case is such an interesting one to increase our understanding about the role of technology within EU society.

1.2 Examples of inconsistency with GM crops in EU agriculture

Back- and forth with 'Amflora'

In 2010, the GM potato Amflora was authorised by the European Commission for commercial cultivation and placed on the market after no less than 13 years (BASF 2010; European Commission Press Release 2010). This authorisation was quite spectacular, as it was the first GM crop to be authorised for commercial cultivation since 2001 (when the revised EU regulatory framework for GM crops came into force). This GM potato only contains amylopectin starch, which makes it a useful resource for the paper industry.

In terms of cultivation, Amflora has never been a great success. Its cultivation started in 2010 on a very small scale in Germany, Sweden and the Czech Republic (on 15 ha, 80 ha and 150 ha of land, respectively). In 2011, Amflora potatoes were only grown on two hectares in Germany. In January 2012, BASF simply ceased marketing Amflora in Europe and even relocated its headquarters from Germany to the USA (VILT 2012). In January 2013, the company also publicly announced that it would stop pursuing EU regulatory approvals for cultivating other GM potatoes, explaining that further investment could not be justified due to the uncertainties in the EU regulatory environment and the ongoing threat over the destruction of crops (Naturalnews 2013).

Then, in December 2013, the General Court revoked the authorisation of Amflora because the European Commission had breached the legal procedure in granting a permit for its cultivation (European Commission Press Release 2013). This withdrawal exemplifies the ongoing political

cat-and-mouse game over GM crop applications within the EU, and demonstrates that top-down attempts to break the political indecision on GM crops simply do not work.

A 'virtually' GM free EU situation

To secure freedom of choice for consumers, EU policy requires the labelling of products that either contain, or are derived from, GM crops (under Regulation (EC) No 1830/2003). This Regulation establishes a system for process-based labelling and traceability, where also food and feed products that do not contain detectable traces of recombinant DNA or novel protein (such as highly refined oils) need to be labelled (Koenig et al. 2004).

The EU labelling standard is amongst the most stringent worldwide, yet it also exempts several product types from labelling, which in itself creates a peculiar situation. For example, the use of processing aids and substances such as additives, flavourings or vitamins produced by GM micro-organisms (under containment conditions) do not require GM labelling. The EU legislation also systematically exempts the labelling of products that are 'produced with' GM crops, such as (GM-fed) animal-derived products (eggs, meat or milk) - while according to EU standards the compound feed that contains GM crops does require a GM label (Gruère et al. 2008). The EU legislation furthermore installs a GM labelling threshold of 0.9% (per ingredient) for the adventitious or technically unavoidable presence of authorised GM crop traces. This means that food products with GM crop traces below 0.9% do not require GM labelling (Gruère et al. 2008). This threshold was established because implementing a zero-tolerance was thought to be unworkable, as the costs of testing and traceability ensuring the complete absence of GM crop traces were substantially higher, and limited detection ability creates technical uncertainty. Also, 100% purity was supposed to be practically impossible in the production of food, feed and seeds - especially because the current GM crops such as GM soya, maize and canola are bulk products.

This labelling standard therefore creates an impracticable situation for certain agribusiness sectors because, for example, imported GM-fed animal products are indistinguishable from non-GM fed animal products on EU supermarket shelves (Inghelbrecht et al. 2014a). Moreover, in the current situation, several Member States also actively build and exploit a strong 'non-GM identity' and create a 'GM safe' country image. They do so by establishing national cultivation bans; by implementing wide isolation distances in their national coexistence frameworks (Beckmann et al. 2006); or by means of a nationally defined non-GM label such as the labels 'Gentechnikfrei' in Austria, 'ohne Gentechnik' in Germany and 'sans OGM' in France (Gaugitsch and Heissenberger 2012; Ramessar et al. 2010; RT America 2015). These non-GM labels differ in scope and

stringency, while several other Member States silently forbid the use of a non-GM label, such as Belgium. Ironically, with France as an example, 'Le portail des professionnels de l'agriculture' recently reported that no less than 75 to 80% of the imported soya beans used for fodder production in France are genetically modified (Reussir.fr 2015). Yet this GM crop use remains largely hidden, as there is no need for labelling of GM-fed animal-derived products in the EU.

Therefore, by balancing this pragmatism and feasibility, on the one hand, and guaranteeing freedom of choice on the other, the current GM labelling standard creates a 'virtual' or 'apparent' GM crop free situation in the EU, as, in practice, GM crops are used and processed, and to a limited extent also cultivated, mainly for feed production, without being labelled accordingly.

The scientific 'GM potato war'

In May 2011, a Belgian field trial with GM potatoes (resistant to the fungal potato-disease late blight) was demonstratively destroyed by protesters (VILT 2011). These protesters included representatives of environmental non-governmental organisations (NGOs), members of the Belgian organic sector's umbrella organisation and members of the Flemish Green Party. In addition, "alarmed by the activists' announcement [to destroy the GM field trial], a group of approximately 300 scientists – who were morally supported by the Flemish Ministry of Agriculture and the largest Flemish farmers' union – organised a counter-protest to defend a scientific freedom to perform the trial under the banner of 'Save Our Science'. Yet, despite this counter-protest, and despite the presence of a police force, a group of 'field liberators' took the field trial by storm in the afternoon and partly destructed it" (De Krom et al. 2014 pg. 2).

This field trial demonstration ended up in Court, with strong media coverage in the light of 'scientific vandalism' (although the opposition was not oriented against science) (Knack 2011). It was more an attempt to re-politicise the current way in which GM field trials are permitted in Belgium. Namely, today, a GM field trial is only concerned about safety, or risk, and this makes the field trial approvals an exclusively scientific safety dilemma. Instead, these protesters want to open up the conflict on alternative futures for agriculture (De Krom et al. 2014).

This so-called 'GM potato war' can therefore be interpreted as a demand to debate our technological future in EU agriculture. The key political questions about a GM field trial are then *socio-technological* ones - such as whether or not a highly technologised type of EU agriculture is desirable. These are questions that cannot be answered by scientists alone. However, this differs from today's political approach to GM field trials where exclusively *techno-scientific* questions are

posed – such as whether or not risks implicated in the experiment are acceptable, and whether or not a precautionary principle should be applied to approve or forbid the experiment. These are questions that presuppose a structuring role for science (De Krom et al. 2014).

The protesters at the GM field trial therefore had clear political and public ambitions, but the scientific consortium that led the field trial also had social and political ambitions. They wanted, for example, to publicly demonstrate the socio-ecological benefits of these GM potatoes to the wider public by inviting journalists, policymakers, farmers, and citizens to visit the field trial; and the consortium wanted to keep the administrative apparatus of field trial applications in Belgium rolling (De Krom et al. 2014). Therefore, both the field trial and the field trial demonstration can be interpreted as politicised spaces (Gottweis 2008), which shows the particular complexity of the situation with GM crops in the EU.

Ex-Green Party members become the new pro-GMO campaigners

In recent years, several anti-GM activists and ex-members of Green Parties have publicly 'changed their mind' when it comes to opposing GM crops. People such as the former director of Greenpeace UK (Stephen Tindale), or Mark Lynas who was previously associated with Greenpeace and organic trade groups, or Bart Coenen who is an ex-member of Agalev (the previous Green Party in Belgium), have in the last few years almost publicly apologised, so to speak, for getting the facts wrong about GM crops (Bosch 2013; Coenen 2015; Lynas 2013; Wright 2015). They now say that it was completely wrong to oppose GM crops and that the anti-GM opposition by Green Parties ignores the scientific facts about the safety and benefits of GM crops, because these applications conflict with their ideologies.

The Séralini affair

In November 2012, the peer-reviewed journal 'Food and Chemical Toxicology' published a rat-feeding study that pointed to severe carcinogenic effects for the glyphosate-based herbicide Roundup and a Roundup-tolerant GM maize variety (Séralini et al. 2012).

In November 2013, that journal announced the withdrawal of the Séralini et al. paper in response to heavy criticism by the scientific community. Namely, the experimental set-up and the conclusions of the study were strongly criticised as being incorrect for supporting carcinogenic effects, for reasons such as the rat species used was known to be carcinogen-sensitive; or that the number of rats in the different categories was insufficient, etc. Even the European Food Safety Authority (EFSA) publicly formulated a scientific assessment of the paper (EFSA 2012).

Both the journal and the publisher Elsevier (openly) argued that the paper had been retracted because the study was inconclusive, while emphasising that no evidence of fraud or intentional data misinterpretation had been found (Elsevier 2013; Food and Chemical Toxicology 2013; Food and Chemical journal Statement 2013). However, in June 2014, the article was republished in its original form in a different journal, together with the raw data (Séralini et al. 2014). No less than four other journals also offered to republish the paper, but the authors chose the journal 'Environmental Sciences Europe' because this is an open access journal, in order to make the study's findings widely available to the whole scientific community. Environmental Sciences Europe decided to republish the paper "to give the scientific community guaranteed long-term access to the data in the retracted paper […] Environmental Sciences Europe conducted no scientific peer review, because this had already been conducted by Food and Chemical Toxicology, and had concluded there had been no fraud nor misrepresentation. The role of the three reviewers hired by Environmental Sciences Europe was to check that there had been no change in the scientific content of the paper" (Nature.com 2014).

This 'Séralini affair' - as it is called today - points to occurrences and inconsistencies that are peculiar to the case of GM crops in the EU. Since April 2013, 90-day rodent feeding studies have moreover become a mandatory aspect of the GM food and feed risk assessment in the EU (Regulation (EU) No 503/2013). It is, of course, pure speculation as to whether or not this is a direct response to the Séralini et al. paper. In favour of this speculation is the particular timing of the requirement for 90-day feeding trials in the EU, and because the strong scientific and public commotion over this study could cause severe damage to the credibility and image of the EU (if nothing was done). One argument that does not support this speculation is the fact that, in December 2011, EFSA had already published general guidance on 90-day feeding studies at the request of the European Commission (EFSA 2011).

GM crop cultivation in the EU: a re-nationalisation of political decision-making

Every GM crop that is cultivated in the EU requires authorisation. These authorisations occur either under the so-called Deliberate Release Directive (Directive 2001/18/EC), or under the Food and Feed Regulation (EC) No 1829/2003 when the application includes besides cultivation also a request for use in food and feed.

Until recently, the scope of such an authorisation was automatically EU-wide. However, since April 2015, Member States have the opportunity to 'opt-out', meaning that a Member State can request an exclusion for (parts of) their national territory from the scope of authorisation, or Member

States may install reasoned measures to restrict cultivation in all or part of their territory once a GM crop has been EU authorised - based on grounds such as environmental or agricultural policy objectives, town and country planning, or socio-economic impacts, to name but a few (Directive (EU) 2015/412).

At the current time, two thirds of EU states (19 in total) have already filed an opt-out request to the European Commission concerning the cultivation of the GM maize MON 810 in all, or parts, of their territory (RT America 2015). MON 810 is currently the only GM crop that is authorised for commercial cultivation in the EU, being an insect-resistant GM maize which is mainly cultivated in Spain and Portugal (James 2014).

- The full opt-out requests were made by Austria, Bulgaria, Croatia, Cyprus, Denmark, France, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, and Slovenia.
- The opt-out requests for only parts of their territories were made by Belgium (Wallonia) and the United Kingdom (Scotland, Wales and Northern Ireland), while Germany requested a partial opt-out, hoping to pursue more GM crop research (RT America 2015).

Besides MON810, several Member States have also requested opt-outs for still pending authorisations. All these opt-out requests are now communicated to the respective biotech companies to see whether they accept the exclusion of (parts of) the Member States' territory from the scope of the authorisation. If the applicant refuses, a Member State may adopt measures to restrict or prohibit the cultivation in all or part of its territory .

This recent Amendment, called Directive (EU) 2015/412, was established in the interests of democratic choice and was meant to extend Member States' opportunities to include their 'national context' within the EU authorisation procedure for new GM crops. That is because, in the past, several Member States regularly raised safety objections to vote against, or abstain, in the general EU authorisation procedure for new GM crops or Member States invoked safeguard clauses or emergency measures, or both, to prohibit cultivation on their territory (Hristova 2013). It is important to note here the scientific requirements that were needed to justify a national ban on GM crops (Ricroch et al. 2010; Skogstad 2011). Instead, the recent Amendment substantiates political goals beyond the scope of a strict science-based risk assessment of GM crops.

It is unclear how biotech companies will respond to the opt-out requests, or what measures Member States will implement if the biotech companies refuse to exclude their territory from the scope of authorisation. Proponents of GM crops often said that the Amendment breaks rules for the free flow of goods within the internal EU market (e.g. EuropaBio 2014), while opponents of GM crops said it is a weak compromise open to court challenges from biotech companies (e.g. Greenpeace 2014). In particular, many stakeholders were against the Amendment due to a (notably unspoken) underlying notion that Member States are now quietly being asked to cease their opposition to the authorisation of new GM crops for cultivation - because each Member State can now exclude its own territory from the scope of authorisation or install measures - so that the general apparatus for authorising new GM crops in the EU can proceed once again.

If that is indeed the intention of the Amendment, then it can be interpreted as a means to re-empower a science-based authorisation procedure for GM crops. If not, then this amendment is a step towards actually repoliticising the decision-making process for GM crops (going beyond the scope of science) (Hristova 2013). Certainly, this re-nationalisation of the Deliberate Release Directive shows a high level of conflict and complexity within the EU situation for GM crops.

Opposition towards the re-nationalisation of the Food and Feed Regulation

Genetically modified crops also need an authorisation before they can be placed on the EU market as (part of) food or feed (under the Food and Feed Regulation (EC) No 1829/2003).

In recent years, however, a qualified majority among the Member States has not been achieved to vote either in favour of, or against, any proposal put forward by the European Commission for authorising a new GM crop for the EU market. As a result of this indecisiveness between Member States, in theory, according to a pre-Lisbon comitology, the European Commission had to authorise the new GM crop for the EU market when it had formulated an Implementing Act based on a positive safety advice from EFSA (Geelhoed 2014; Swinnen and Vandemoortele 2010; Tosun 2014). It is for this reason that the European Commission has recently proposed legislation to give Member States the opportunity to restrict or prohibit the sale and use of EU-approved GM food or feed on their territory. This is similar to the reason for the Amendment to the Deliberate Release Directive - namely that Member States frequently invoked 'national reasons' unrelated to safety, to justify their opposition to an authorisation, or their decision to abstain (EU Legislation in Progress - Briefing 2015). In the current legislative proposal, the European Commission maintains the responsibility for granting the marketing authorisations for GM crops, but a Member State can

decide whether or not to allow the authorised GM crops onto its territory. These EU authorisations always involve a permit for both food and feed use.

However, the GM market situation differs significantly between food and feed within the EU. There is hardly any GM food present on the EU market, but the EU livestock sector is heavily dependent on imports from countries outside the EU for vegetable proteins, especially soya and soymeal. According to recent figures from Coceral, Fediol and Fefac (2015) - which are the European sector organisations that are involved at a practical level in the trade, shipment, processing, and use of soybeans and soybean derivatives - the area of GM soya in the top three global soybean producing countries in 2014 "was 94%, 93%, and 100% respectively in the USA, Brazil and Argentina […] [on this basis] estimation suggests that the current global availability of commercially usable non-GM soybeans and soybean meal for animal feeding purposes is about 9 million ton […] EU imports of non-GM soybeans and soybean meal for feed were up at around 2-3 million ton [over an average time period of 2012/13 to 2014/15], what is quite a substantial part of what is theoretically available in the exporting countries […] [but] overall EU demand for certified non-GM soybean has largely remained at 3-4 million ton, or about 10% of the total EU demand for soybean meal. Notably, around 800 000 ton of the non-GM soybeans are used for food purposes, coming almost exclusively from the USA" (Coceral, Fediol and Fefac 2015 pg. 3 -5).
It is consequently argued that when Member States choose an opt-out for GM food and feed use on their territory, EU imports of non-GM soybeans for food are unlikely to be strongly affected. For feed, it is estimated that when "all EU countries opt out, the extra costs would increase 2.8 billion euros for the EU livestock sector" (Coceral, Fediol and Fefac 2015 pg. 9). In addition to costs, the option of replacing GM soybean meal in fodder production with domestically grown oilseed, sunflower meal or beet, for example, is not considered to be a feasible alternative by these European sector organisations, because of technical and climatic constraints (Coceral, Fediol and Fefac 2015).

The current proposal to renationalise decisions for the use of GM food or feed, however, has been rejected by both the Council and the European Parliament (in October 2015) (European Parliament News 2015; IFOAM 2015). The main concerns are that the current proposal will (i) disrupt the single EU market, or (ii) prove unworkable within the EU, or (iii) prove unworkable from a legal perspective because important EU trading partners such as Argentina, Brazil and the USA, may challenge a national ban before the World Trade Organisation (WTO).

At the current time, December 2015, there are 68 GM crops authorised for food and feed use in the EU. These include soybean, maize, oilseed rape, cotton and sugar beet (EU Legislation in

Progress- Briefing 2015). Another 58 applications for authorisation are still pending (17 of them have already received a positive opinion from EFSA). Overall, this illustrates long delays in the current EU authorisation process for new GM crops for food and feed use.

To enable the EU livestock sector to practically cope with these EU delays, in 2011, a 'low level presence' (LLP) threshold was established (under Regulation (EU) No 619/2011). Previously, when a GM crop was not, or not yet, authorised in the EU a zero-tolerance level was applied, which meant that if the EU imports were contaminated with accidental traces of such a GM crop, these raw materials were systematically rejected or even destroyed in the EU. However, countries such as Argentina, Brazil or the USA have a much faster implementation rate for GM crops than the EU. This increases the likelihood of minute traces of such GM varieties being present in imports that arrive in the EU (Coceral, Fediol and Fefac 2014, 2015).

Now, with the so-called low level presence threshold, this zero-tolerance has been replaced with a legal tolerance level of 0.1%. This 0.1% applies only to contamination in imports that are processed in feed applications and if the contamination comes from a GM crop for which an EU authorisation is pending, or for which the EU authorisation has expired (which occurs after 10 years). The LLP is therefore a practical solution to maintain the appearances of a virtually GM free EU situation.

1.3 The 'lock-in'

The above examples illustrate several incoherent practices and a great deal of internal conflict on GM crop applications within the EU. EU policy thereby tries to provide a balance between safety, freedom of choice, pragmatic solutions, scientific disputes and inconsistent actor positions, in an international context with higher implementation rates for GM crops worldwide, especially in countries on which the EU depends for its vegetable proteins.
Specifically, we observe a situation where moving forward in trying to implement GM crops has been systematically blocked (e.g. with Amflora), while at the same time attempts to fully exclude GM crops from EU agriculture have been systematically prevented (e.g. with the LLP). A central premise in this dissertation is therefore that GM crops are not 'the problem'. Rather, the ambiguous situation where both proponents and opponents seem powerless in terms of fully excluding or promoting these applications within EU agriculture is the problem. We will refer to this situation as a 'deadlock' or 'lock-in', which is a state in which progress is impossible as a result of the counteraction of opposing forces. The GM potato war, the Séralini affair, or the Amflora case are all examples of the tangibility of this lock-in.

As this PhD dissertation will show, understanding this lock-in will require us to take a systemic perspective on the technology lock-in for GM crop applications. A perspective where the role of actors is analysed, more specifically how they understand 'the problem' with GM crops in EU agriculture and how they reproduce the lock-in through their daily practices. It will also be important to look at the institutional context within EU agriculture and at the role of this technology itself, because both determine the sociotechnical practices in which GM crops are currently embedded. All of this will be explained in the next chapter, which will also introduce our empirical work. Further, Chapter 2 will present the objectives and research questions for this PhD, and it will explain why we have selected the conceptual lens of 'wicked problems' to analyse the case study of GM crop applications in the EU.

This chapter has been adapted from: Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2014). The 'wickedness' of GM crop applications in the European Union. International Journal of Agricultural Management, 3(2), 67-69.

CHAPTER 2.
PROBLEM SETTING AND RESEARCH QUESTIONS: A WICKED PROBLEM LENS

The complexity of wickedness: a balancing act.

CHAPTER 2.
PROBLEM SETTING AND RESEARCH QUESTIONS: A WICKED PROBLEM LENS

"The streets have been paved, and roads now connect all places; houses shelter virtually everyone; the dread diseases are virtually gone; clean water is piped into nearly every building. But now that these relatively easy problems have been dealt with, we turn our attention to others that are much more stubborn." (Rittel and Webber 1973)

2.1 The problem of the problem statement with GM crops

As shown in the introductory chapter, the EU situation with GM crops can be characterised as a 'lock-in'. A large number of actors are involved in the ongoing discussion about these applications, probably due to the fact that GM crops have a direct impact on both our food production and consumption practices, and hence potentially impact on the cultural meaning attached to our food. Yet it seems difficult to define the 'real' problem at stake here, as so many problem statements form part of the discussion and they relate to so many different social issues. To give a few examples, GM crops raise issues related to the globalisation of EU agriculture; the privatisation of agriculture and scientific research; the loss of biodiversity and genetic contamination; the effects of pesticide resistance; the power of farmers in the supply chain organisation; the patentability of life forms; the role of technology in food security; the principle of subsidiarity in relation to an EU internal market; or the power of multinational industries in food production (Rosendal 2005; Knight and Gao 2009; Pechlaner 2010; Lemmens 2014, Dibden et al. 2013; Inghelbrecht et al. 2014b; Stephan 2012).

It therefore seems that the actual problem is defining 'the problem' with GM crops. We may call this 'the problem of the problem statement'. This contestation occurs because the way in which a problem is framed influences the solution for the problem in question. This means that whatever problem statement with GM crops is proposed by any actor, it will always be a strategic and deliberative framing with a view to gaining political and social support (Hisschemöller and Hoppe 1995; Hajer 1995). No problem statement can therefore be called 'neutral' or 'objective'. Instead, it is value-loaded and related to a long-term vision with particular priorities. The way the problem is defined, therefore frames the scope of conflict and inherently expresses what is considered to be 'right' or 'wrong', or what is considered to be relevant knowledge, or not (Wesselink and Hoppe 2011; Grint 2005).

This makes the political problem statement on GM crops highly important, because it will frame the scope of 'permitted' conflict in the EU. Problem definition is therefore as much a part of the policy-making process on GM crops as problem solving and any EU political problem statement on this matter will have to obtain societal legitimacy to be able to successfully regulate these applications (Hisschemöller and Hoppe 1995). In the next section, we will therefore discuss in more detail how the problem with regard to GM crops is framed politically in the EU GM crop legislation.

2.2 The problem of the political problem statement with GM crops

The EU GM crop legislation is a risk regulation that aims to protect human and animal health, and the environment, in combination with the principle of individual freedom of choice and extensive traceability. It therefore has three keywords: 1) a risk-based focus with a prominent role given to science; 2) informed choice; and 3) traceability. In the wording of the European Commission, "the European Union has established a legal framework to ensure that the development of modern biotechnology, and more specifically GMOs [genetically modified organisms], takes place in safe conditions. The legal framework aims to: [1] Protect human and animal health and the environment by introducing a safety assessment of the highest possible standards at EU level before any GMO is placed on the market; [2] Put in place harmonised procedures for risk assessment and authorisation of GMOs that are efficient, time-limited and transparent; [3] Ensure clear labelling of GMOs placed on the market in order to enable consumers, as well as professionals, (e.g. farmers, and food feed chain operators) to make an informed choice; [4] Ensure the traceability of GMOs placed on the market. The building blocks of the GMO legislation are: Directive 2001/18/EC on the deliberate release of GMOs into the environment; Regulation (EC) No 1829/2003 on genetically modified food and feed; Directive (EU) 2015/412 amending Directive 2001/18/EC regarding the possibility for the Member States to restrict or prohibit the cultivation of GMOs on their territory; Regulation (EC) No 1830/2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms; and Regulation (EC) 1946/2003 on transboundary movements of GMOs. These main pieces of legislation are supplemented by a number of implementing rules or by recommendations and guidelines on more specific aspects" (European Commission 2015a, last update 16/10/2015).

At the heart of the EU's legislative framework, lies the Deliberate Release Directive (2001/18/EC) which makes explicit reference to the precautionary principle. This is a normative principle used for making decisions under conditions of scientific uncertainty. There is also the Food and Feed

Regulation (EC) No 1829/2003, which explicitly states that, in some cases, scientific risk assessment alone cannot provide all the information upon which a risk-management decision should be based, thereby implying that other legitimate factors may also be taken into account (Recital 32 of the Food and Feed Regulation). In theory, both scientific and non-scientific considerations can therefore find expression in the EU authorisation procedure for new GM crops (Geelhoed 2014; Hristova 2013).

Depoliticisation in the decisions of the European Commission

In practice, the openness towards including non-scientific arguments in the EU authorisation procedure for new GM crops is only peripheral at certain stages, for many reasons:

(1) Both the European Commission and EFSA have never included non-scientific arguments in any of their opinions or draft decisions so far (Hristova 2013).

(2) The explicit structural divide between EFSA as the science-based risk-assessment body, and the Commission as the risk-management body, puts the Commission under an obligation to explain (not justify, however) why it deviates from an EFSA opinion in drafting authorisation decisions. This gives scientific knowledge a privileged position at this stage of decision-making (EC 2000; Geelhoed 2014; Pellizzoni 2010).

(3) EFSA has been systemically confident in its assessment of the safety of GM crops, while a certain level of uncertainty is a key requirement to invoke precautionary measures (Geelhoed 2014; Jensen and Sandøe 2002).

(4) The Commission has the opportunity to consult an ethical committee before drafting its authorisation decisions for new GM crops (Articles 29 and 33 in the Deliberate Release Directive and the Food and Feed Regulation, respectively, in Geelhoed 2014). So far, however, this has not occurred.

(5) EFSA has clearly stated that it is not empowered to integrate ethical and social concerns in its conclusions. EFSA thereby frames the issue in a way that renders lay expertise irrelevant in its opinions (Kritikos 2009) and it posits a strict science/policy divide.

(6) Although the Commission states that defining acceptable levels of risk for society is an eminently political responsibility - thereby making a sharp distinction between scientific risk assessment and risk management- the Commission's interpretation of the precautionary principle presents 'risk' as an objectifiable matter. It considers scientific uncertainty mainly as 'just a lack of knowledge' that can be addressed through further

research, which again de-emphasises the political nature of risk (Devos et al. 2014; EC 2000; Myhr 2007; Myhr and Traavic 2002).

(7) All the communication between the Commission and the Member States during the risk-management phase involves only science-based elements (Hristova 2013). Besides, the Amendment Directive (EU) 2015/412 itself shows that the Commission prefers to allow a (post-decision) renationalisation and to maintain the universalism of science, rather than including non-scientific arguments in the general authorisation procedure for GM crops (Hristova 2013). The Commission has, in fact, so far failed to formally recognise that Member States' positions about GM crops may be formed by internal societal concerns, such as socio-economic impact assessment, ethical reasons, or different views on politically acceptable levels of risk, whereas these national concerns and differences were already reflected in the different Member States' regulatory models before harmonisation in a centralised EU GM crop legislation in the early 1990s (Shaffer and Pollack 2004).

(8) Stakeholder involvement in this authorisation decision seems to be of a more procedural nature and largely symbolic (Kastenhöfer 2011). This is because the risk regulation stresses the importance of a scientifically based argument, where ideological argumentations are often difficult to verify given that there are strong pressures within the EU regulatory system to express concerns about GM crops in terms of this factual evidence of specific risks (Devos et al. 2014; Maeseele et al. 2013; see also Chapter 1).

Therefore, on the one hand, we observe the strong preference for scientific argumentation and scientific facts in the authorisation decisions of the European Commission (the first actor in the risk management process). This can be interpreted as an ambition *to depoliticise* the problem at stake with GM crops - whereby through depoliticisation 'politics' is subordinated in the decision-making process, by shifting responsibility from politics to techno-scientific networks (Klika et al. 2013; Maeseele et al. 2013; see the glossary on depoliticisation). Namely, in formulating authorisation decisions (Implementing Acts) for new GM crops under Directive 2001/18/EC or Regulation (EC) No 1829/2003, the Commission has always followed the opinions of EFSA (apart from one occasion); it has never included non-scientific factors in its decision or made reference to non-scientific concerns; and the Commission has only ever delayed the adoption of an authorisation decision in order to request or consult additional scientific studies (Geelhoed 2014). Consequently, this risk-management phase in the authorisation process has, in practice, little added value above and beyond the scientific risk assessment performed by EFSA (Hristova 2013). Yet, to some extent, this stance by the Commission is understandable, due to its internal commitments for safeguarding the integrity and the seamless functioning of the internal EU

market, the Commission's recall to the WTO dispute on the moratorium, and, especially, because "as a technocratic body it simply does not have the mechanism at its disposal to resolve such politically charged issues" (Hristova 2013 pg. 123).

A political impasse in the comitology amongst Member States' risk managers

On the other hand, the democratic legitimacy that is given to Member States' representatives in the Standing and Appeal Committees to vote on the Implementing Acts that the Commission formulates, points to a political impasse in the comitology (Geelhoed 2014). Member States' risk managers have so far been unable to adopt a position by a qualified majority, either for or against the authorisation of a new GM crop for the EU market (Devos et al. 2014). The presumed ability to incorporate different national priorities and concerns by means of deliberation in the EU legislation therefore does not seem to work very well (Klika et al. 2013).

Reasons for this may be that there is distrust within some Member States about accepting the scientific opinions of EFSA's GMO Panel. This would point to scientific disagreement as the main reasons for opposing a GM crop authorisation. This is plausible because, for example, "the EFSA's overconfidence in the safety of GMOs, limits the possibilities of risk managers for the ultimately political determination as to whether a risk should be taken, while acknowledgement of uncertainty is a necessary precondition for precaution. Its objective scientific opinions disguise its subjective choices regarding the framing of the issue, appropriate methodologies and ultimately the most competent 'scientists'. Whereas the EFSA does not perform its own safety tests […] [this] would thus allow for broad-scale collection of data and for multilevel cooperation and debate. In practice, the one-door-one-key structure […] has taken a more hierarchical shape with the EFSA at the top" (Geelhoed 2014 pg. 7). This all creates a perception, and even a practice, of 'EFSA science *vs* national science' (Hristova 2013), because communication between the Commission and the Member States continues to be solely science-based.

It is also plausible that a political impasse in the comitology amongst Member States' risk managers is the result of opposition to the depoliticised way of formulating authorisation decisions by the Commission, or because for some Member States the problem definition for GM crops simply goes beyond science and offering individual freedom of choice. Member States' national positions can be formulated based on a broader set of considerations, such as political levels of risk tolerance, public opinion or agricultural policy goals.

Either way, Member States' risk managers have been unable to adopt a position by qualified majority, leading to a political impasse in the comitology "that may be attributed to the procedure's disregard for *diversity in and beyond science*" (Geelhoed 2004 pg. 7, own emphasis in italics). Also, the wide diversity in national coexistence frameworks for cultivating GM crops points to divergent national stances on GM crops and different political interpretations of available scientific data. Member States have imposed isolation distances ranging from 15m to 800m to prevent contamination by MON810 in non-GM crop commodities (below the 0.9% GM labelling threshold) (Devos et al. 2008; Ramessar et al. 2010). Member States, such as Austria and Poland, have also been able to accommodate their own national stances by using Article 114(5) TFEU (for protecting environments that are specific to that Member State), and several Member States have succeeded in restricting or prohibiting the marketing of specific authorised GM crops on their territory using safeguard clauses (Skogstad 2011). In the light of the recent Directive (EU) 2015/412, national bans may, in the future, be obtained more easily or on grounds not related to environmental or health risks (see Chapter 1).

There is no such thing as 'the' EU political problem statement

Based on the above explanation, it seems that there is no such thing as 'the' EU political problem statement for GM crops. In general terms, there is the 'A + B' political problem statement of scientifically proven safety *plus* individual freedom of choice, which forms the basis for authorising GM crops in the EU. (Traceability is considered here as a necessary prerequisite to guarantee freedom of choice). In practice, however, the implementation of this risk regulation proceeds in a depoliticised way up to the level of the European Commission, while Member States' risk managers have been unable to adopt a position by qualified majority, resulting in a political impasse at this stage of the risk management decision-making process.

In addition, there is also societal and other political resistance to this risk regulation, or to its current implementation. Several examples illustrate this.

- The European Parliament, which is not formally involved in the authorisation of new GM crops, has already adopted several resolutions calling upon the Commission to withdraw a draft implementation decision for a new GM crop. This occurred, for example, against the cultivation of the Bt-maize 1507 or against the placing on the market of a stacked herbicide-tolerant GM soybean (MON 87708 × MON 89788 (MON-877Ø8-9 × MON-89788-1)) (European Parliament 2014, 2016).
- Proponents, sceptics and opponents use different evidence to describe or interpret the data (or lack of data) with regard to the potential consequences of GMO use and release in various

ways; "such factual divergences cause disagreement about which facts are relevant, and what research needs to be initiated" (Myhr 2007 pg. 4). The result is a discursive battle about the value of specific scientific 'facts' and a situation in which contesting parties gather their own body of relevant facts, by seeking so-called knowledge coalitions (Böschen et al. 2010; Devos et al. 2014; Séralini et al. 2012). In a knowledge coalition, "different researchers, policy-makers and stakeholders work closely together in producing knowledge" (van Buuren and Edelenbos 2004 pg. 296). This leads to 'knowledge fights' where stakeholders talk across each other (a 'dialogue of the deaf') with arguments that are often scientifically valid, yet which differ fundamentally from each other in terms of the underlying paradigms upon which they are based (Goeminne 2011; van Eeten 1999).

- Persistent demands for socio-economic impact assessments of GM crops (e.g. Fischer et al. 2015); or the recent 'GM potato war' in Flanders (De Krom et al. 2014; see also Chapter 1) also illustrate a lack of societal support for (the current implementation of) this risk-based regulation.
- In addition to the recent Amendment to Directive 2001/18/EC, there are also ongoing attempts to renationalise the Food and Feed Regulation because of Member States' persistent invocation of 'national reasons', unrelated to safety, to justify their opposition to, or their decision to abstain from, the general authorisation procedure (see also Chapter 1).

Overall, this brings us to an essential starting point of analysis in this PhD dissertation, namely that it is important to acknowledge 'the problem of the political problem statement' and that it is important to consider, and reconsider, the institutional role of science in relation to this problem. This presents an interesting opportunity to analyse our case from a so-called 'wicked problem' perspective, as will be explained in the next section.

2.3 Our analytical lens: a wicked problem perspective

Addressing the lock-in for GM crop applications within EU agriculture is difficult, because the nature of the problem itself involves *inter alia* the following characteristics:

- there is multi-actor involvement with self-interests, different norms and values;
- formulating 'the problem' is the problem;
- there are knowledge coalitions which generate their own body of scientific facts;
- there is an attempt to depoliticise the problem at the level of the European Commission, but this ambition has not obtained full political or societal legitimacy to structure the problem accordingly;

- there is a political impasse in the comitology amongst Member States' risk managers to reach a qualified majority for or against the authorisation of new GM crops;
- top-down political decisions fail to break the impasse;
- scientific set-ups are used to stimulate debate;
- …

This list of characteristics suggests a need to reinvestigate the role of science in relation to the problem analysed and it shows a need for 'problem structuring' of what precisely constitutes the problem. It therefore seems appropriate and relevant to analyse the lock-in for GM crop applications within EU agriculture from the perspective of 'wicked problems'. A wicked problem is characterised by both factual uncertainty and normative dissent (Grin et al. 2004), and it is generally defined as "that class of social system problems [that] are ill-formulated […] where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing […] they are complex, intractable, and difficult to resolve" (Waddock 2013 pg. 91-92).

Well-known examples of wicked problems are land grabbing, global climate change or nuclear energy (Dentoni et al. 2012). To address these problems, a great number of people are required to change their mindsets and practices, because addressing a wicked problem requires change in the institutional set-up in a sociotechnical system, such as agriculture, and more specifically in the norms, rationalities, formal rules or symbolic values for particular objects within that system (Fuenfschilling and Truffer 2014).

Classifying the GM case as a wicked problem might seem a desperate measure, at first glance, as these problems are said to be resistant to solutions. Yet, the lens of wicked problems is a valuable analytical perspective for analysing this complex case study (as this PhD dissertation will show), because it takes a systemic perspective on the problem and by doing so it allows us to include daily practices in modern EU agriculture within the problem statement. The latter is especially relevant because GM crops seem to 'fit well' with these dominant practices. Therefore, rather than just reflecting on the technical problem itself, the concept of wicked problems allows us to reflect upon social values within EU agriculture.

In the remainder of this chapter, the concept of wicked problems is further discussed and used to determine the objectives and research questions of this dissertation in Sections 2.5 and 2.6.

2.4 Wicked problems in a nutshell

The existence of wicked problems is a result of increasing complexity in society at three levels (Loorbach 2010; van Buuren and Edelenbos 2004):

- The level of society itself, as a result of more decentralised decision-making structures within EU society, as there is an opening-up of the regulatory regime to non-state actors and non-scientists (Gottweis 2008; Waddock 2013).
- The level of the problems facing our society. As Rittel and Webber (1973) originally formulated it: "the streets have been paved, and roads now connect all places; houses shelter virtually everyone; the dread diseases are virtually gone; clean water is piped into nearly every building; and so on […] But now that these relatively easy problems have been dealt with, we have been turning our attention to others that are much more stubborn" (pg. 156).
- The level of dealing with these problems, due to a lack of clear direction and orientation in terms of long-term social objectives and who is in charge of this.

Key in the definition of wicked problems is their highly contested problem statement. This means that "the formulation of a wicked problem *is* the problem […] [because] problem understanding and problem resolution are concomitant to each other" (Rittel and Webber 1973 pg. 156). That is because defining the problem is, in fact, all about defining where to start moderating system change. Wicked problems consequently have no right or wrong solutions, but only a better or worse (set of) solutions from a given viewpoint. Accepting the possibility of incommensurable framings amongst multiple stakeholders is therefore the essence of the wicked problem concept.

Wicked problems are also characterised by the absence of clear cause-effect relationships and are therefore said to be multi-causal. For instance, conflicts on GM crops can be considered as a consequence of globalised agricultural practices, (a desire for) human control, or the power of science, to name but a few. Wicked problems are also a symptom of another problem, because, for example, "food supply and growing systems are connected to multiple other systems: the use of land resources, fertilizers (and consequent pollution), distribution, sales, marketing, pricing, and a huge range of other systems and stakeholders involving just about everyone" (Waddock 2013 pg. 98). A wicked problem also co-evolves with every attempt to address it, causing it to change irreversibly. Attempts to address a wicked problem are therefore one-shot operations as "every implemented solution is consequential. It leaves 'traces' that cannot be undone. One cannot

build a freeway to see how it works, and then easily correct it after unsatisfactory performance" (Rittel and Webber 1973 pg. 163).

Summarised, wicked problems are generally conceptualised as follows (Rittel and Webber 1973; Inghelbrecht et al. 2014a):

(1) Wicked problems are difficult to clearly define. They have no clear problem statement, because the nature and the extent of the problem are unclear.
(2) Wicked problems have multilevel actor involvement with many interdependencies. There are multiple conflicting goals at stake that all emphasise different risks and priorities.
(3) Wicked problems are multi-causal, meaning that different stakeholders put forward different causes to define the problem.
(4) Wicked problems have no clear solution. Effective solutions require coordinated action by a range of stakeholders and they involve changes at all levels of society (a transition).
(5) Attempts to address a wicked problem often lead to unforeseen consequences and introduce new problems.
(6) Wicked problems are unstable and evolve over time.

A more 'classical' view on wicked problems defines them as 'problems of social policy' for which the standard paradigm of science 'as a problem solver' is not applicable because of new views (and practices) on rationality, uncertainty and top-down government within society (Hisschemöller and Hoppe 1995; Wesselink and Hoppe 2011). In a more recent characterisation, wicked problems are analysed in terms of why these problems are persistent, based upon the theorem of duality of structure (Schuitmaker 2012). In the following paragraphs, both perspectives are discussed in more detail.

2.4.1 Wicked problems as a socio-political type of problem

The classic conceptualisation of wicked problems is based on Hisschemöller and Hoppe (1995) and Wesselink and Hoppe (2011), who present wicked problems as a part of the well-known typology that is shown in Figure 2.1 This typology "rests on a definition of a problem as a deviation between an 'is' and an 'ought'. The 'is' is the available relevant knowledge for understanding the problem, in which there can be more or less certainty. The 'ought' is represented in the norms, values, ideals, and interests at stake in defining the problem, in which there can be more or less ambivalence or ambiguity. These two dimensions yield four problem types" (Wesselink and Hoppe 2011 pg. 399). In this typology, 'the role of science' and 'the role of policy' changes along

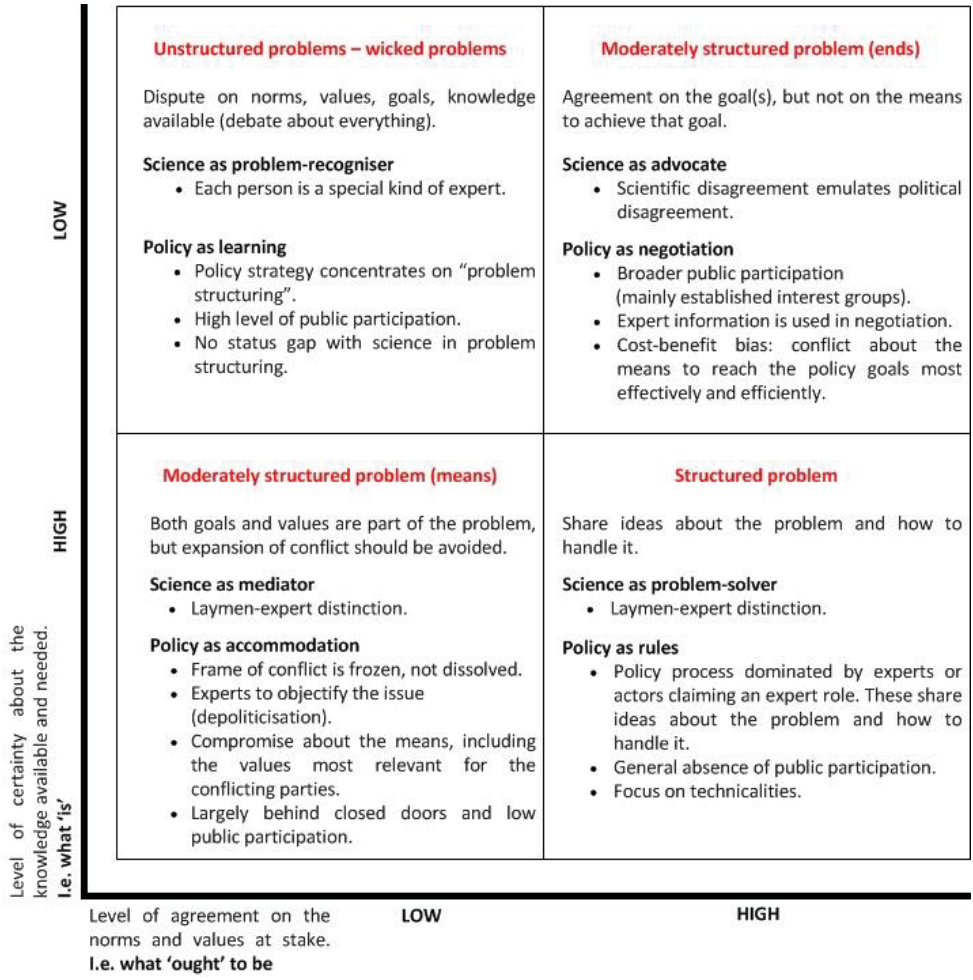


Figure 2.1. Four types of socio-political problems. This scheme is based on Hisschemöller and Hoppe (1995) and Wesselink and Hoppe (2011).

the type of socio-political problem that is at stake. Figure 2.1 discusses the main characteristics of each problem type in more detail. Under this typology, wicked problems have both factual uncertainty and normative dissent, as there is a high level of disagreement on the norms and values at stake, and there is strong disagreement and conflict concerning the available or required knowledge to characterise and address the problem. This means that, in dealing with in a wicked problem, scientific experts have no more authority than non-experts in defining or structuring the problem (the expert-laymen division is superseded by different types of knowledge, such as experiential knowledge).

This role for 'science as a problem-recogniser' in the concept of wicked problems is combined with a strategy of 'policy as learning' to cope with these intractable controversies (Wesselink and Hoppe 2011). Key to this approach is that policy makers concentrate on 'problem structuring'. In this process, policy makers create a trust environment, where a heterogeneous group of actors, who have multiple views and frames on the problem, are brought together. The individuals participating in this process should be actors who have the capacity to 'judge together' or who have a 'social rationality' (Hisschemöller and Hoppe 1995; Loeber 2007). In simple terms, this means that these actors should have the open-mindedness to engage in debate in such a way that arguments and counterarguments for multiple aspects of the problem will reframe their original position. For this, the "actors must invest time so that a broad range of options, even those elements taken for granted, may become part of the discussion […] A moment will come at which (almost all) actors involved have come to reframe their original position. In other words, the interaction process will have produced some really new ideas. This conception of the problem will probably take special notice of one (or some) vulnerable interests that were not taken into account before" (Hisschemöller and Hoppe 1995 pg. 54-55). This strategy of 'policy as learning' therefore involves an iterative process of structuring the actual problem at stake by allowing conflict on the issue to expand.

Interestingly, this means that the process of problem structuring with the role of science as problem-recogniser (no superior role for science when structuring the problem) seems to be *a way forward* in addressing a wicked problem; while the knowledge coalitions that are said to be typical for wicked problems seem to *reproduce* the wicked problem, causing its strong factual dissent (van Buuren and Edelenbos 2004; van Eeten 1999).

Both the strong normative and factual dissent that is part of the lock-in for GM crops within EU agriculture fits this typology of a wicked problem (Grin et al. 2004). Parties bombard each other with science, while the normative debate remains deadlocked. This urges us to stress that the different roles for both science and policy in the above typology are always socially negotiated, through strong discursive battles, and obtain, at best, societal legitimacy for a particular role, in relation to a particular problem.

2.4.2 Wicked problems are persistent: the duality of structure

Schuitmaker (2012) argues that the abovementioned characteristics of wicked problems are underdeveloped in defining why these problems are so persistent: "it [a wicked problem] is used to label (symptoms of) problems that appear to be complex, uncertain, difficult to manage, and

difficult to grasp, but as such provides no way for unravelling how the persistence of these problems actually works. A better understanding can help new practices, like niche-innovations, to overcome enduring problems, contributing to a transition or system innovation" (Schuitmaker 2012 pg. 1021). In this conceptualisation of wicked problems, these problems are "a tangible problem on the system level, but it is the underlying structure that makes it persistent" (Schuitmaker 2012 pg. 1023). It is consequently the structures in place within a sociotechnical system, such as agriculture, that reproduce a wicked problem, as a negative side-effect, of several regime elements that form the institutional set-up of the system. Wicked problems therefore have a 'structural complexity' based on the theorem of duality of structure (Giddens 1984) - see the following section.

In this view, the lock-in for GM crops is a tangible problem e.g. demonstrated by the action and counteraction of first publishing and then withdrawing the Séralini et al. paper (2012, 2014); or for example by first authorising and then recalling the authorisation of Amflora, as explained in Chapter 1. However, this tangible problem is, then, persistent because of the underlying structure within EU agriculture, e.g. because imports and private sector-driven institutions are normalised within EU agriculture; or because a vegetable protein dependency, or scale economies, or vertically coordinated supply chains are daily practices within EU agriculture.

Under this view, analysing the lock-in for GM crops as a wicked problem will require us to define how the problem is embedded within EU agriculture, by defining the specific resources, relationships, symbolic capital and other structural features that make this lock-in so persistent.

Wicked problems and the duality of structure

The theorem of duality of structure details how social structures shape agents' practices, while these agents' practices constitute and reproduce structures. Structures are thus socially structur*ing* for human practices. Both 'rules and resources' are part of structures. *Rules* comprise both formal and informal rules, such as legislative texts, constitutions, contracts, or assumptions and unspoken rules about how to behave in public or how to treat other people. *Resources* involve both human and non-human resources, such as knowledge and dexterity, but also objects (Sewell 1992).

The resources in the system are defined by the rules in place, while the validity of these rules is itself dependent on these self-defined resources that sustain them. Social power in EU agriculture is thus not at all intrinsic to objects or actors. For that, objects or actors must be 'activated' by the

structures in place to become resources or agents with an allocated value, relevance and prestige. For example, soya within EU agriculture is not a resource per se but the high (also symbolic) value of soya e.g. in the current production of compound feed makes it a resource. Or, the social power of supermarkets in the overall supply chain is the result of supply chain governance that is sustained by our weekly supermarket visits.

The structures in place sustain systems and make wicked problems persistent over time. At the same time, these dual structures also present an opportunity to address a wicked problem, by redesigning agents' practices in order to try to transform the structures in place. In this case, it will be necessary to "highlight where and how regime elements manifest themselves in the daily practice of agents that try to take on enduring problems" (Schuitmaker 2012, pg. 1024). That is because all actors in a system are partially institutionalised by the established regime logic within that system; a logic that automatically reproduces the very problem that these actors are trying to address. Addressing the lock-in for GM crop applications within EU agriculture will therefore require second-order learning, where an actor's perspective on the solution as well as his goals, vested interests, standards and values are questioned and modified (Poppe et al. 2009) (see the glossary on second-order learning).

2.5 Objectives and research questions

The above characterisation of wicked problems leads to the conclusion that when characterising the lock-in for GM crops within EU agriculture, it is essential to:

(1) Obtain an understanding of the actors' interpretations of 'the problem' with GM crops; and how these actors reproduce the lock-in within their daily practices.

(2) Obtain an understanding of the role of science in different problem framings and how this relates to the current policy strategy.

(3) Obtain an understanding of the sociotechnical practices in which GM crops are currently embedded and how this relates to the prevailing practices within EU agriculture.

(4) Obtain an understanding of the rules and resources (i.e. the structure) within the EU agricultural regime; because the lock-in is reproduced, as a negative side-effect, of several regime elements that form the standard 'rules of the game' within EU agriculture.

This identifies three important angles for analysing the lock-in under study. These are the perspective of the actors, the perspective of the system's structure and the perspective of the

technology itself (more specifically the sociotechnical practices in which GM crops are currently embedded). This is presented in Figure 2.2.

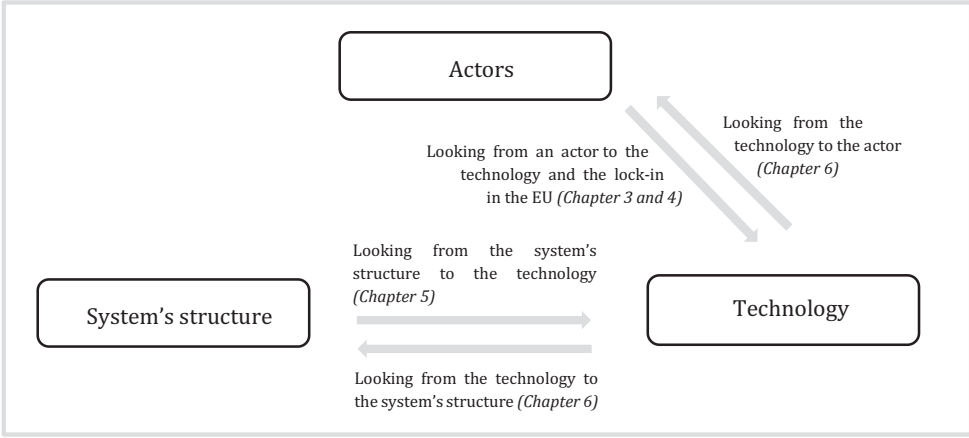


Figure 2.2. Three angles to analyse the lock-in for GM crop applications within EU agriculture. This will be the focus in this dissertation.

Therefore, the dissertation will have two major objectives.

Objective1: The first objective is to characterise the systemic and socially reproduced nature of the lock-in for GM crop applications within EU agriculture.

Objective2: The second objective is to characterise, and if possible enhance, the ongoing debate about GM crops in the EU beyond a Yes/No framing.

This results in the following research questions which are addressed in the dissertation:

RQ1: Which regime elements reproduce the systemic, sociotechnical lock-in for GM crop applications within EU agriculture?

RQ2: What elements can enhance the public debate about this technology beyond a Yes/No framing?

RQ3: How do actors in agribusiness give meaning to GM crops and the current lock-in within EU agriculture? Can we identify thematic congruence in this discursive space? How do these perceptions link to actors' strategic behaviour?

RQ4: Why can apparently incremental innovations have a hard time breaking through? Why is this incremental innovation so highly contested?

RQ5: How can GM crops, within their current use context, actively mediate human interpretation and human practice within EU agriculture?

The first and second research questions are straightforward translations of the overall objectives of the dissertation, namely to characterise the systemic, sociotechnical lock-in for GM crop applications within EU agriculture (RQ1); and to understand the current process of debate about GM crops, and, if possible, to formulate a way forward in this regard (RQ2). The third research question analyses the lock-in mainly as a socio-political problem, by defining, in more detail, the incommensurable framings of the problem (also in relation to how people act) (RQ3). The fourth research question characterises the lock-in from a system's structure perspective (RQ4), by looking at societal developments within the EU agricultural regime during the first R&D period for agricultural biotechnology. This can partly explain why this particular incremental innovation is such a controversial and highly debated one within EU society (RQ4). The fifth research question explains the strong opposition to GM crops in the EU based on the technological amplifications and reductions in GM crops within their current forms of use (RQ5).
The five research questions are answered throughout Chapters 3 to 6. Table 2.1 shows which chapter contributes to answering which research question(s).

	CH 3	CH 4	CH 5	CH 6
RQ1: Which regime elements reproduce the systemic, sociotechnical lock-in for GM crop applications within EU agriculture?	✓	✓	✓	✓
RQ2: What elements can enhance the public debate about this technology beyond a Yes/No framing?			✓	✓
RQ3: How do actors in agribusiness give meaning to GM crops and the current lock-in within EU agriculture? Can we identify thematic congruence in this discursive space? How do these perceptions link to actors' strategic behaviour?	✓	✓		
RQ4: Why can apparently incremental innovations have a hard time breaking through? Why is this incremental innovation so highly contested?			✓	✓
RQ5: How can GM crops, within their current use context, actively mediate human interpretation and human practice within EU agriculture?				✓

Table 2.1. Schematic overview of how each chapter addresses the research questions in the dissertation.

Our overall understanding is that public debate about GM crops is legitimate, but that the rather exclusive focus of discussion on whether or not to accept these applications, misses the essence

of the debate. Namely, ethical concerns develop in close interaction with material developments and this technology can take moral routines out of their 'passive' or 'cold' self-evident invisibility and, as Swierstra and Rip (2007) state, transform moral routines into 'active' or 'hot' ethics again (see the glossary on ethics and morality). Under this view, discussion about GM crops becomes an interesting way to debate how we have organised, or want to organise, our society. This can provide an opportunity to exchange the current 'battle for the best framing' of the problem with GM crops, to a public consideration (perhaps reconsideration) of what 'our' societal norms and priorities are, or should be, in EU society (Goorden 2004; Verbeek 2011, 2014). To do so, this also requires a systemic characterisation of the lock-in, which in our opinion nicely interconnects the two major objectives of this dissertation.

2.6 Outline of the dissertation

Figure 2.3 illustrates the structural outline of this dissertation, by showing the theoretical lenses that were taken to analyse the lock-in under study. The figure details several theoretical contributions of the work and it highlights several main findings about this lock-in. In the following paragraphs, the content of each chapter is briefly discussed.

In Chapters 3 and 4, we will focus on different interpretations of 'the problem' from the *actors'* perspective (Figure 2.2), by defining how actors in the agribusiness sector give meaning to GM crops and the current lock-in within EU agriculture. Both analyses also look at how agribusiness actors reproduce the lock-in through their daily practices. To do so, the methodology of discourse analysis is used, as discourse analysis studies interpretative processes and specifically allows us to look at different 'frames of meaning' underlying a problem statement.

Chapter 3 specifically sketches the discursive space for GM crop applications from an industry perspective. We discuss how actors in agribusiness give meaning to GM crops and the current lock-in, and how these perceptions link to actors' strategic behaviour (RQ3). Then, discourse coalitions are defined and we explain how these discourses influence the business decision-making process for several agricultural industry sectors on whether or not to include genetically modified ingredients in products for the EU market. We can build on this discourse analysis to empirically classify the accompanying regime that embeds GM crops within EU agriculture as a wicked problem.

In Chapter 4, we then try to find thematic congruence amongst these incompatible discourses based on a conventional content analysis. We therefore introduce the concept of a 'structuring

arena' (SA) as a next step in the analysis of how actors in agribusiness give meaning to GM crops and the current lock-in within EU agriculture (RQ3). This SA framework is an analytical model that categorises, and maps, *congruence in the type of explanations and argumentations* that are present in agribusiness actors' divergent discourses on GM crops and thus ground an agribusiness actor's overall interpretation of GM crops and the current lock-in within EU agriculture (Chapter 3). It was constructed by means of coding the interview data into meaningful categories, which were then positioned on a two-dimensional grid along the lines of the innovation diffusion models.

Chapters 5 and 6 will explore, in more depth, the relationship between the technology (the sociotechnical practices within which GM crops are currently embedded) and the existing structure within the EU agricultural regime.

Chapter 5 will analyse this relationship from the perspective of the *system's structure* (Figure 2.2). For this analysis, we will use the multi-level perspective (MLP) of transition theory. The MLP has a central notion of co-evolution between technological and societal processes and this makes it a well-elaborated heuristic (guiding the analyst's attention towards relevant questions and patterns) to look at the wider context and sociotechnical networks in which the design and first implementation of GM crops took place. More specifically, this chapter outlines an analytical narrative that describes how first generation GM crops (with improved agronomic traits) were related to the existing structures within EU agriculture, during the first R&D period for agricultural biotechnology. Furthermore, it discusses whether the niche protection functions (shielding, nurturing and empowering) that are typically stipulated for successful implementation of radical innovations might also be relevant for successful implementation of apparently incremental innovations such as GM crops. The chapter thereby provides a better understanding of why apparently incremental innovations can still have a hard time breaking through (RQ4).

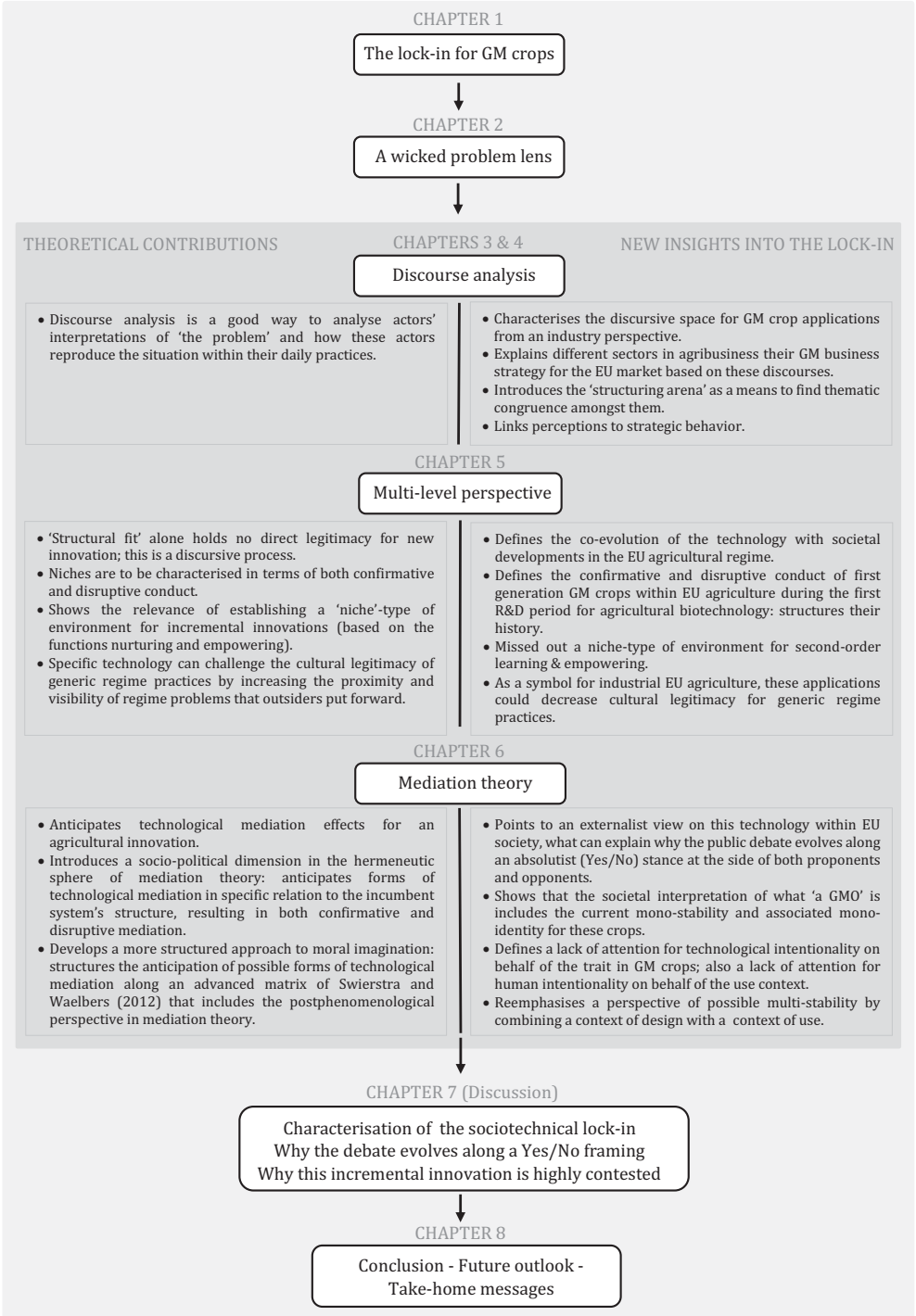
Chapter 6 will specifically discuss the relationship between GM crop applications and the system's structure from the perspective of the *technology* (Figure 2.2). This is done by analysing the moral significance of GM crops with respect to the human interpretation and human practice that is normalised by the structures in place within EU agriculture. The analytical framework that is used for this analysis is mediation theory. Mediation theory explains contestation about a technology based on how technology and humans mutually constitute each other (thus also looking at how technology affects actors; Figure 2.2). In particular, we discuss how there is only one type of biotechnology 'at stake' in the ongoing EU debate and that, in this so-called mono-stability in the public interpretation of this technology, we observe a mono-identity in which all crop/trait

combinations and user practices are generalised and seen as equal. Then, we discuss the moral significance of GM crops within this current mono-stability and make some suggestions about how to anticipate technological mediation effects in future technology design. This chapter will therefore help to analyse how GM crops, within their current use context, can actively mediate human interpretation and human practice based on the concept of mediation theory (RQ5). The analysis will also help to define why GM crop applications are such a highly contested incremental innovation within the EU (RQ4). It will show a new way to debate this technology beyond a Yes/No framing (RQ2); and the analysis will identify several regime elements that socially reproduce the sociotechnical lock-in under study (RQ1).

In Chapter 7, we will further characterise the three discourses that were discussed in Chapters 3 and 4 in terms of their epistemic and de-/re-politicising nature. On this basis, we will urge that the current legislative formulation of the problem with GM crops along an 'A + B' format of scientifically proven safety plus individual freedom of choice – and especially how it has been brought into practice - stipulates the 'wrong' socio-political problem with GM crops. Namely, the formulation, and implementation, of the risk-based EU legislation on GM crops puts forward a moderately structured problem (means), where the high levels of conflict in relation to values and concerns about GM crops are mitigated by trying to reach a compromise on the means to enable a future consensus. However, this has led to the current practices of depoliticisation at the level of the European Commission and a political impasse in the comitology amongst Member States' risk managers. We therefore suggest focusing instead on problem structuring and discuss the new role for policy, science and gatekeepers in relation to this problem structuring. Chapter 7 also formulates an answer to our two objectives. We first provide an overview of our characterisation of the sociotechnical lock-in for GM crops, and then characterise the ongoing EU debate about GM crops beyond the scope of Yes/No framing and explain why this particular incremental innovation had such a hard time breaking through.

In the concluding Chapter 8, we discuss the relevance of taking a wicked problem lens to analyse this lock-in and we formulate a number of policy recommendations and topics for future research. We also generalise our case study findings to make some suggestions about future technology design, and we define a number of 'take-home messages' from this dissertation.

Figure 2.3. Schematic representation of the structural outline of this dissertation. This figure is presented on the next page.


CHAPTER 1
The lock-in for GM crops
CHAPTER 2
A wicked problem lens
THEORETICAL CONTRIBUTIONS
CHAPTERS 3 & 4
NEW INSIGHTS INTO THE LOCK-IN
Discourse analysis
• Discourse analysis is a good way to analyse actors' interpretations of 'the problem' and how these actors reproduce the situation within their daily practices.
• Characterises the discursive space for GM crop applications from an industry perspective.
• Explains different sectors in agribusiness their GM business strategy for the EU market based on these discourses.
• Introduces the 'structuring arena' as a means to find thematic congruence amongst them.
• Links perceptions to strategic behavior.
CHAPTER 5
Multi-level perspective
• 'Structural fit' alone holds no direct legitimacy for new innovation; this is a discursive process.
• Niches are to be characterised in terms of both confirmative and disruptive conduct.
• Shows the relevance of establishing a 'niche'-type of environment for incremental innovations (based on the functions nurturing and empowering).
• Specific technology can challenge the cultural legitimacy of generic regime practices by increasing the proximity and visibility of regime problems that outsiders put forward.
• Defines the co-evolution of the technology with societal developments in the EU agricultural regime.
• Defines the confirmative and disruptive conduct of first generation GM crops within EU agriculture during the first R&D period for agricultural biotechnology: structures their history.
• Missed out a niche-type of environment for second-order learning & empowering.
• As a symbol for industrial EU agriculture, these applications could decrease cultural legitimacy for generic regime practices.
CHAPTER 6
Mediation theory
• Anticipates technological mediation effects for an agricultural innovation.
• Introduces a socio-political dimension in the hermeneutic sphere of mediation theory: anticipates forms of technological mediation in specific relation to the incumbent system's structure, resulting in both confirmative and disruptive mediation.
• Develops a more structured approach to moral imagination: structures the anticipation of possible forms of technological mediation along an advanced matrix of Swierstra and Waelbers (2012) that includes the postphenomenological perspective in mediation theory.
• Points to an externalist view on this technology within EU society, what can explain why the public debate evolves along an absolutist (Yes/No) stance at the side of both proponents and opponents.
• Shows that the societal interpretation of what 'a GMO' is includes the current mono-stability and associated mono-identity for these crops.
• Defines a lack of attention for technological intentionality on behalf of the trait in GM crops; also a lack of attention for human intentionality on behalf of the use context.
• Reemphasises a perspective of possible multi-stability by combining a context of design with a context of use.
CHAPTER 7 (Discussion)
Characterisation of the sociotechnical lock-in
Why the debate evolves along a Yes/No framing
Why this incremental innovation is highly contested
CHAPTER 8
Conclusion - Future outlook -
Take-home messages

CHAPTER 3.
THE NON-GM CROP REGIME IN THE EU:
HOW DO INDUSTRIES DEAL WITH THIS WICKED PROBLEM?

It is all about perspective.

CHAPTER 3.
THE NON-GM CROP REGIME IN THE EU: HOW DO INDUSTRIES DEAL WITH THIS WICKED PROBLEM?

"The way we choose to see the world, creates the world we see. Your thoughts. Your perception. Your reality. The more interpretations we gather, the easier it becomes to make sense of the world." (Barry Neil Kaufman)

This chapter analyses how actors in agribusiness give meaning to GM crops and the current lock-in within EU agriculture, and how these perceptions are linked to actors' strategic behaviour (RQ3). The chapter thereby provides an understanding of actors' interpretations of the problem at stake; and how these actors reproduce the lock-in within their daily practices.

The chapter first outlines three discourses that shape the discursive space for GM crop applications in the EU from an industry perspective, (i) GMIs as an agricultural payoff; (ii) GMIs as a marketing threat; and (iii) non-GM crops as a preset end goal. The chapter then discusses how these discourses influence the GM business decision-making process in different agricultural industry sectors, these being the agricultural biotech industry, the compound feed industry, the food manufacturing and marketing industries, the potato industry and the organic farming sector. Finally, the chapter empirically classifies the accompanying regime that embeds GM crops within EU agriculture as a 'wicked problem'.

3.1 Introduction

If we assume that only legitimate reasons exist for the (non)adoption of a new technology, then the current ways of implementing GM crops in EU agriculture and on the EU market must follow a certain logic (Vanclay et al. 2013) (see Chapter 1). So, in order to understand the industry position, their perceptions of the problem at stake, and to understand how they reproduce the lock-in within their daily practice, the methodology of discourse analysis was selected. This methodology is used to analyse how actors in agribusiness give meaning to GM crops and the current lock-in within EU agriculture, because the societal interpretation of what a GM crop 'is', is not limited to how it is defined under EU legislation (Masip et al. 2013; Morris and Spillane 2011). Products such as eggs, meat and milk derived from GM-fed animals, for example, are not considered legislatively as genetically modified ingredients (GMI) and are therefore sold on the EU market without a GM label, while in several societal interpretations these products are GMIs. In an analytical interpretation, this leads to a 'fictitious' or 'apparent' non-GM crop regime in

which GM crops are currently embedded within the EU. This creates a tricky and challenging environment in which to conduct business (Inghelbrecht et al. 2015).

Discourse analysis studies interpretative processes and specifically enables us to look at different 'frames of meaning' underlying a problem statement (Hajer and Versteeg 2005). On this basis, three more specific research questions for this chapter were formulated, as follows:

(1) Which discourse(s) influence the GM business policy of an agribusiness company for the EU market?

(2) How are these discourses reflected in practice? How do they influence the business decision-making process of several agricultural industry sectors on whether or not to include GMIs in products for the EU market?

(3) Can we empirically classify the accompanying regime that embeds GM crops within EU agriculture as a wicked problem?

The chapter outlines three discourses that shape the discursive space for GM crops and their applications within the EU from an industry perspective. It also discusses how these discourses influence the business decision-making process within several agricultural industry sectors. These are the agricultural biotech industry, the compound feed industry, the food manufacturing and marketing industries, the potato industry and the organic farming sector. Next, due to the high level of conflict, discord and complexity involved, the accompanying regime that embeds GM crops within EU agriculture was classified as a 'wicked problem' based on the characteristics outlined by Rittel and Webber (1973). This regime is understood as a "whole complex of scientific knowledges, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructures that make up the totality of a technology" (Kemp and Hoogma 1998 pg. 182).

3.2 Methodology

Definition of discourse: a 'frame of meaning' to interpret the world

'Discourse' is an umbrella term for collective ways of talking and thinking about issues. We use the term here to mean discourse as a 'frame', where "the use of language in specific situations is no longer the focus of attention, but the way in which a certain frame of reference or 'frame of meaning' mediates the use of language […] It exists in the minds of people and in the social networks of which they are part. It is based on experience and history, of which they may be aware or unaware, but which, in either circumstance, influences how they speak and act" (Arts and

Buizer 2009 pg. 342). A discourse, then, is a set of linked understandings and ideas which structure how actors interpret, act and interact in the world (Humphreys 2009). It involves collective sense-making around specific issues (in this case GM crops and the current lock-in within EU agriculture). A discourse therefore proposes something similar to the meaning-searching 'homo interpretans', where meaning arises from interpretation and where human behaviour is not primarily driven by objective interests, rationality, power dissimilarities or social norms, but rather by collective interpretations and meanings of the world (Arts and Buizer 2009).

Different frames of meaning can, for example, involve different values, priorities, and different epistemic cultures (Humphreys 2009). They structure an actor's perceptions of what is right or wrong, true or false, important or not, desirable or undesirable. Discourses therefore lead to different collective interpretations of 'the world' that are often incompatible. These discourses are 'toolkits' or 'repertoires' that actors use to make sense of, and also structure, human action. This involves normalising some (types of) practices at the expense of others, because discourses shape the boundaries of thought/reasoning/understanding, and so they shape action (Humphreys 2009). Discourses are therefore said to be both a medium and an outcome of human action. Discourses enable or constrain action, and actions affect the success of the discourse - where the most successful discourses are the ones we consider normal and common sense. In our interpretation of a discourse, both the agency and structural characteristics of a discourse are emphasised and a discourse is constitutive of, and constituted (i.e. re-produced and transformed) by both social practices and institutions (De Krom and Dessein 2013; Hajer and Versteeg 2005).

The data : open-ended interviews with actors in agribusiness

To perform the discourse analysis, we have applied a multi-sector research design (Table 3.1). Our prime data were obtained from 41 semi-structured interviews undertaken between 2010 and 2011. Both (i) individual companies, with a general product portfolio for either the national, European, or world market, as well as (ii) representatives of the national and European federations, of each of the following sectors were included in the sample: the agricultural biotech industry, the compound feed industry, the food manufacturing and food marketing industries, the organic farming sector, and the potato industry (both the fresh potato market and industrial processors of chips and French fries). Sampling was initiated in these multiple sectors, as each of them represents an important category of chain actors within the overall agribusiness chain. The potato industry was specifically included in the analysis as potatoes are one of the first GM crops likely to become available for cultivation and/or processing in the EU in the shorter term (next 5-10 years) (Stein and Rodríguez-Cerezo 2010). The GM criterion was therefore more likely to be

prominent on the companies' business agenda.

Agricultural industry sector	Number of stakeholders	Reasons for inclusion
Agricultural biotech industry	6	Chain actors with different views on GM crop applications are included.
Compound feed industry	6	
Food manufacturing industry	6	
Food marketing industry	7	
NGOs/Organic farming sector	5	
Potato industry (both fresh market & industrial processing)	11	The crop characteristics of potato make GM potatoes one of the most likely crops for cultivation in the EU in the short term. This increases the likelihood that the GM criterion is a point of consideration for the sector.
Total	41	

Table 3.1. Overview of the number of in-depth interviews performed in each agricultural industry sector. The table shows the reasons for inclusion of a stakeholder group in the stakeholder sample. This stakeholder group selection was verified and extended by using a non-probability snowball sampling technique. Data-collection stopped when data-saturation was reached in each sector.

The stakeholder sampling took place in Flanders (the Northern part of Belgium) and the initial stakeholder group selection was verified and extended by using a non-probability snowball sampling technique (Onwuegbuzie and Leech 2007). This has resulted in the inclusion of environmental NGOs in the unit of analysis - as numerous companies argued that you cannot understand a company's GM business policy for the EU market without fully understanding the stance of NGOs (this influence by third parties on actors in the supply chain is commonly referred to as private governance; Busch 2011). Including food, feed and social actors in the final research sample takes into account much of the complexity of the industrial players in the EU agricultural setting and incorporates chain actors with extreme views on GM crops. Nevertheless, extending this case-study research to cover other categories of chain actors may reveal additional discourses.

The interviews explored the range of reasons for (commercial) (dis)interest in GM crops and their applications for the EU market; actors' overall perception of GM crops and the current EU

situation; actors' experiences; etc. Much attention was paid to iteratively revising the interview guide so as to avoid any predetermination. The full interviews were transcribed ad-verbatim and used as input for the analysis. Data analysis started by reading all the data repeatedly to achieve immersion and obtain a sense of the whole (Tesch, 1990). Then, a code book of 68 codes (themes) was developed by means of open coding. Open coding breaks down large amounts of data into smaller, more manageable conceptual components based on content (Corbin and Strauss 1990; Mortelmans 2007).

"A code in qualitative inquiry is most often a word or short phrase that symbolically assigns *a summative, salient, essence-capturing, and/or evocative attribute* for a portion of language-based or visual data […] Just as a title represents and captures a book or film or poem's primary content and essence, so does a code represent and capture a datum's primary content and essence." (Saldana 2009 pg. 3, own emphasis in italics). This form of explorative coding was necessary to introduce an initial structure to the interview data in NVivo9, in order to capture the diversity present in the interviews. While remaining close to the actual data, this form of abstraction was, of course, a first data selection. During this coding process, the interview data were broken down into phenomena, which are transcript fragments that represent discrete ideas, thoughts, incidents, events, or acts that were mentioned by the respondents (De Mey et al. 2011). Similar phenomena mentioned by two or more respondents were considered relevant for the analysis and labelled as a concept. The concepts that emerged were further analysed and grouped into themes based on content (Triste et al. 2014). This was a strongly iterative process, starting from an initial set of interviews where phenomena were labelled to enable a grouping of similar phenomena under a common heading (concepts). Then additional interviews were systematically added, broken down into pieces, labelled and grouped again. In these steps, similar or new concepts and themes could emerge. Attributing labels and categorising the data in this way, was thoroughly verified by two researchers (inter-coder reliability), to ensure a logical and objective classification of the interview data. We have also included general checking opportunities in this coding scheme, where several colleagues were asked to perform an open coding of the same (parts of) interviews. Their labelling was collectively discussed within the group and mutually compared to our developing code book for accuracy and completeness. This iterative process, back-and forth between new and already coded data, continued until all the collected data were analysed and labelled based on a final coding scheme of 68 bottom-up defined codes (themes), which give thematic insight into how an actor understands, defines and characterises GM crops and the current EU situation for GM crops, alongside actors' own strategies and practices on the EU market. This systemic coding of the interviews was the starting point for both this discourse analysis and the content analysis in Chapter 4.

The data analysis

The aim of the discourse analysis was to obtain a general understanding of how meaning is attributed to GM crops and the current EU situation for GM crops. As a discourse is social, actors' words and their meaning depend on where they are used, by whom and to whom (Sapsford and Jupp 2006). It was consequently necessary to include the institutionalised setting in our discourse analysis and to focus on the range of explanations that an actor considers (either intentionally, or otherwise) when (s)he discusses GM crops and the current EU situation. Important questions to perform this analysis were therefore: what public and/or institutional perceptions about GM crops and the lock-in are considered important by the actor?; what is seen as 'right', 'wrong', or 'normal'?; which norms are mentioned when discussing GM crops?; what practices are automatically associated with these applications?; etc.

On this basis, three distinctive discourses on GM crops and their applications were identified by analysing shared arguments, norms, values, motivations and practices present within a substantial group of actors - resulting in collective frames for giving meaning. They are discussed in Section 3.3. The three discourses were triangulated, revised and refined in two ways. One, by using multiple sources of secondary data (collected between 2010 and 2013). These were (i) legislative texts, press releases, scientific literature, company websites, and grey literature updates; (ii) regular updates from key individuals; and (iii) multiple rounds of feedback and discussion in international fora. Secondly, in the triangulation, the preliminary discourses were reviewed in relation to the systematics in the 'structuring arena' (Chapter 4). Thereby, we specifically asked ourselves questions such as: (how) does an overall outlook on agriculture influence each of the three preliminary discourses?; (How) does an overall perspective on science influence them?; (How) does a value assessment of the benefits and risks of GM crops have an influence?; (How) do economic considerations have an influence in each of the three preliminary discourses?; (How) do perceptions of the GM and non-GM agricultural market have an influence?; How (extensively) does the EU policy legislation have an influence? (e.g. are GM crops interpreted in relation to the 0.9% labelling threshold, the animal-derived product exemptions, etc.).

As discourses are closely related to particular groups of actors who subscribe to them, the 'discourse coalitions' associated with each discourse were also defined in the analysis (Hajer 1993). The primary focus here was on defining whom the actor represents, or purports to represent. A discourse coalition was thus based on shared meanings and interpretations, but did not necessarily represent a strategic coalition (Hajer 1993). To avoid the strengthening of certain coalitions at the expense of others, the recruitment of new interviewees was undertaken using the

snowball sampling method. This involved explicitly asking the interviewees to suggest other respondents for the study, both with the same and different positions and views in comparison to their own. This request guaranteed the inclusion of a diverse set of interviewees in the study and avoided the formation of predetermined coalitions.

3.3 Three discourses shaping companies' GM business policy for the EU market

This section describes three discourses that shape the discursive space for GM crops and their applications in the EU: GMIs as an agricultural payoff, GMIs as a marketing threat, and non-GM crops as a preset end goal. We describe them separately and discuss how these discourses influence or shape the business decision-making processes of several agricultural industry sectors.

3.3.1 GMIs as an agricultural payoff

The first discourse 'GMIs as an agricultural payoff' is determined by an agro-industrial perspective on agriculture. Due to its protein dependency, EU agriculture is considered as a major importer of (certain) raw materials. GM imports are seen as an intrinsic necessity and a 'by-default' economic reality in EU agriculture, as GM crops are extensively cultivated and processed in other parts of the world. Moreover, the EU GM crop regulatory approval system that authorises GM crops for import and for processing in food and feed applications (Regulation (EC) No 1829/2003) is criticised for being slow and detached from its scientific base. This regulation attracts disapproval for disrupting the free flow of raw materials worldwide, while simultaneously establishing severe import restrictions in the EU. This inability to implement GM crop applications in EU agriculture, and particularly GM imports, is regarded as a threat to the agricultural capacity of the EU (in the long term).

Table 3.2 illustrates how each stakeholder group advocates, opposes, or denies the first discourse. According to our analysis, the first discourse is strongly advocated by the agricultural biotech and compound feed industries. This identified discourse coalition is illustrated by the boxes outlined in bold in Table 3.2. However, this discourse influences their decision-making process in different ways, as we explain next.

Agricultural biotech industry	"China looks at it [GM crops] in terms of food security, of food supply for its own population. If as a consequence there are shelves emptied in Europe [because of GM crop trace contamination], that is not their concern [...] If things evolve to a situation where one loses the ability to compete on the world market because it is produced cheaper elsewhere. In the end, EU agriculture will not continue with a couple of niche products. If you realise that 10 to 15 years ago USA farmers produced 10% less when compared to the EU. Today, the picture is reversed. Their production is 15% higher than in Europe for maize, wheat [...] You cannot maintain a situation where one continent produces much more efficiently, and another not. So farmers will ask for these products [GM crops]."
Compound feed industry	"The whole world makes no problem of it [of GM crops]. Europe wants to oppose, but Europe has no power anymore [...] Before, Europe was the big player. Today everything goes to China and China poses only limited restrictions. We cannot stop it."
Food manufacturing industry	Depending on the company's product portfolio: "There is a lack of availability [of non-GM] in some conventional ingredients due to increased cultivation of GM crops [...] For feed, we do not demand GM-free from our farmers, because we know it is a volume issue." "There are a lot of warnings about it [problems in sourcing non-GM]. It is mentioned in all our argumentation and there are examples [where non- GMI sourcing becomes very difficult] that bother us [...] Those small ingredients which are difficult to substitute, that is what bothers us the most, for example soy lecithin."
Food marketing industry	Scattered viewpoints: "That is one of the biggest problems. If Europe is too difficult [referring to its certified non-GM raw material demand] they [exporters of raw materials] have other customers who are not that difficult. So why would they still choose Europe? China asks no questions." "As non-GM progresses to become a niche product, we expect an increased tolerance for GM crop traces in non- GM materials."
Potato industry	Processing industry: "Potatoes for the EU market are produced in Europe. And for America they are cultivated there." Fresh potato market: "Europe is actually such a big player in this system, it can simply impose its GMO criteria on niche markets."
Organic farming sector	"Industrial agriculture does not have a future [...] Farmers with such a production, who speculate on the world market - because they sell their pork in Russia, South-Korea, etc. - will not continue in Flanders in the future. Because of the fact that if you want to be a part of that market, even when including GM feed, then you have so many other competitive disadvantages: these being small production areas, high wages, etc. You will not make it there and GMO will not change that. That means that agriculture in Flanders, in the long term, will evolve with a focus on quality, more organic."

Table 3.2. Discourse 1 'Genetically modified ingredients as an agricultural payoff'. This table illustrates how each stakeholder group advocates, opposes, or denies the first discourse. The bold box indicates the stakeholder groups which strongly advocate this discourse.

Agricultural biotech industry

Because GM imports are considered to be a by-default and imposed reality in EU agriculture, the agricultural biotech industry files applications to obtain authorisation for new GM crops in the EU for both import and processing in food and feed applications. Although the regulatory requirements to obtain this authorisation create high compliance costs, financial investment continues because GM imports are perceived as a by-default reality. Conversely, R&D investment in GM crops specifically for cultivation in the EU has been considerably reduced and applications to obtain regulatory authorisations for GM crop cultivation in the EU are more or less at a standstill. This diminished investment is a result of the EU GM crop regulatory approval system, which is very expensive, time-consuming and totally unpredictable. It creates significant cost pressures, provides low levels of return on guaranteed investments and offers a highly uncertain outcome:

> "What company can wait 30 years for an [EU regulatory] approval [for EU cultivation]. It is not possible" (Agricultural biotech company a).

Moreover, the sector is sceptical about the likelihood of positive regulatory changes in the near future, particularly because the regulatory approval system has often been criticised for simply not being applied. The EU itself is held responsible for impeding the potential of EU agriculture. However, this victimisation stance is nuanced:

> "Herbicide-resistance and insect-resistance technologies, drought, nitrogen efficiency. These traits are the same for Europe and America" (Agricultural biotech company b), and "They [BT and MON810] are already crossed-in in the right varieties, but they are not necessarily finished. It will take a certain number of years before they will be cultivated on a large scale, but new things not at all." (Agricultural biotech company c)

The sector favours an evidence-based scientific approach for the regulatory approval system. Yet, many of the agricultural biotech firms strongly doubt the ongoing value of science in resolving the current stalemate on GM crops in the EU. This is because: (1) science can never be 100% certain about the impact of GM crops on the environment and public health, (2) the overall EU GM crop legislation has been designated as a political game that simply misuses science, (3) retailers are defined as powerful 'gatekeepers' in the supply chain who just market whatever generates the highest profit, and (4) NGOs are said to dictate to supermarkets as they are able to mobilise the public. In other words, investment in GM crops for EU cultivation is reduced as an outcome of the EU political landscape, while the continued investment in obtaining authorisation for GM crops for import and processing in the EU resides in the discourse that GM imports are a by-default

reality in EU agriculture.

Compound feed industry

The sectoral decision by the Belgian compound feed industry to systematically stop non-GM compound feed production (from 2007 onwards) was made on a strict by-default basis:

> "GM crops do not provide any advantage to the feed industry, so we are neutral in that regard. But one thing is for sure, we need access to them because they have the lowest price; there is no alternative" (European compound feed federation).

Before 2007, the decision-making process was dominated by the direct commercial fear of losing regular customers by not complying with their non-GM product criterion. Today, a cost-effective systematic refusal of GM imports is perceived as impossible under the present non-GM crop regime in the EU. Non-GM raw materials without GM crop trace contamination are seen as a niche product that is increasingly difficult to source. This economic unease has been increased by the 'unfair competition' in relation to the GM criterion at the level of the end product in the EU: namely, animal products derived from non-GM fed animals have to compete with cheaper animal products derived from GM-fed animals (yet these are not correspondingly labelled).

Recently, the sector has developed an alternative marketing identity which is technology-neutral and disconnected from the (non-)GM product criterion (Bemefa 2011). This Certified Socially Responsible (CSR) compound feed was an economic opportunity for many companies when compared to the economic burden of a systematic non-GM compound feed production. Nevertheless, CSR compound feed remains a somewhat national phenomenon (mainly in Belgium, The Netherlands and England). So overall, the GM business policy of the Belgian compound feed industry is the outcome of experience that GM imports cannot be rejected altogether in EU agriculture, within the current regulatory landscape, due to a number of insurmountable economic and practical problems.

3.3.2 GMIs as a marketing threat

The second discourse 'GMIs as a marketing threat' is instigated by a black-or-white choice marketing consideration, where GMIs might just be a business opportunity and where compliance with the social norm is centralised. In this regard, the EU GM crop legislation must safeguard a supply of non-GM raw material for the EU so as to ensure freedom of choice (both now and in the future). The obligatory labelling of GMIs - above the 0.9% labelling threshold set out under Regulation (EC) No 1830/2003 - is criticised, on the one hand, for stigmatising GM crop

applications, while on the other hand it is considered necessary to inform consumers. Table 3.3 shows how each stakeholder group advocates, opposes, or denies the second discourse. This discourse is strongly advocated by food manufacturers, retailers and stakeholders in the potato industry, which together form a discourse coalition (Table 3.3, boxes outlined in bold).

Agricultural biotech industry	"Retailers have played on the biotech issue to suit themselves: all of a sudden we sell organic products, we sell non-GM products. For retailers, lots of people are prepared to pay money [...] You are talking about companies that are agri-commodity companies. We are seed producers. Our client is our farmer, not the consumer. We do not sell directly to consumers."
Compound feed industry	"For example, retail requested GMO-free feeding only in the last three months for dairy cattle and only in the last weeks for broilers. What happened during the first phase of the life cycle did not matter. But they communicated GMO-free to their customers. That is also the reason why in 2007 we stopped [a systematic non-GM compound feed production]. We saw this hypocrisy by the retail sector. Or you ask it for the whole life cycle, maybe even go back to previous generations, if you want to play it clean."
Food manufacturing industry	**"We depend completely on our customers. If the consumer does not want it anymore, then it is over."**
Food marketing industry	**"We must be careful not to take over the role of the government. Their role is to define what is safe and what is healthy. Our role is as follows: if a consumer does not want to follow the government's advice, then we must still offer him freedom of choice within the regulatory framework."**
Potato industry	**"As soon as there is consumer aversion, then they are very afraid to lose market share and they hold back [...] You can develop them [GM potato varieties], but which processor will stick his neck out if he does not have a buyer who sees the point. Because it is not the processor who determines what is going to happen, actually it is Burger King, McDonalds, the catering industry, the food service and retail. And retail is nothing but competition. For example, X [retailer] does not consider it because then he has 50 people from Greenpeace striking in front of each shop the next day."**
Organic farming sector	"Organic will have serious problems because their consumers expect that it contains no GMO [...] That GMO enters the regular distribution channels, also the food sector. But you have a number of categories in agriculture where it may not be used because people do not want that, such as in organic [...] It doesn't matter whether the contamination is above or below 0.9% [...] Consider it is between 0 and 0.9%; legally there is no decertification of the batch. What happens in practice, is that the organic farmer will not sell the product as organic, because he does not want to take the risk that his name becomes associated with that product [a GM-trace containing organic product], because also Testaankoop [consumer organisation] does GM crop trace analyses."

Table 3.3. Discourse 2 'Genetically-modified ingredients as a marketing threat'. This table shows how each stakeholder group advocates, opposes, or denies the second discourse. The bold box indicates the stakeholder groups which strongly advocate this discourse.

Food manufacturing industry

The decision by food manufacturers to include or exclude GMIs in food products aimed at the EU market is strongly influenced by this second discourse. Food manufacturers perceive GMIs as a stigmatising item, so they opt for a non-GM sales strategy because it is the most predictable and coherent strategy. However, in practice, many food manufacturers use products that are derived from GM-fed animals and many of their food products may contain GM crop traces below 0.9%.

Non-GM products are not a preset goal for this sector, but just a means to comply with EU consumer demand. GMIs can offer benefits and are a business opportunity, but not on the current EU consumer market. Non-GM product sales are an economic reality for the sector, best described as a workable model, because some ingredients are difficult to source in a form certified as non-GM. Any additional costs faced as a result of the current non-GM sales strategy will depend on the company's product portfolio:

> "Despite having almost all kinds of products in our portfolio, we are actually less affected by GM. This might sound strange, but some companies are affected much more severely than us, because they are in a very specific branch, such as processing cereals" (Food manufacturing processor a).

Food marketing industry

Retailers' decisions to commercialise or restrict GMIs in their stores are also strongly influenced by this second discourse. As they experience GMIs as a stigmatising item, there is considerable commercial unease regarding exposure to public criticism and loss of market share by openly selling GMI-containing products. A non-GM sales strategy seems the most predictable and coherent strategy to cope with the uncertainties of the current EU marketing environment. Typical of retailers, this GM strategy is framed as a part of the overall corporate policy on sustainability, or healthy food products, for example. Similar to food manufacturers, retailers also process products derived from GM-fed animals in their generic brand products. Moreover, the animal products they market may be derived from GM-fed livestock and the food products sold may contain GMI traces below 0.9%. Non-GM product sales on the EU market are not a preset goal, but a means of complying with the current consumer demand, and vice versa. Using GMIs are not, therefore, a preset goal but at best a business opportunity when there is significant consumer acceptance. For most retailers, the non-GM sales strategy is economically tolerable and comparable to other product quality criteria:

"We do some controls [on GM crop traces], but they are limited. We do not check international brands, mainly only products from our own generic brand" (Retailer a).

Potato industry

Stakeholders in the potato industry see GM potato varieties on the EU market as a (long-term) business opportunity. In their view, GM varieties can offer benefits, but these are limited in the current EU marketing environment. GM potato varieties are just a business opportunity, not a goal in themselves. This sector anticipated that only a few GM varieties will enter the EU market in the forthcoming years. These will most likely be French-fried potatoes for industrial usage, as these varieties generally have a market of sufficient size to be commercially attractive for agricultural biotech firms to genetically modify them. Non-GM sales are not a preset end goal for the sector, but currently a self-imposed responsibility to comply with customer demands. Non-GM certificates are almost a standard in this sector; a guarantee that is relatively easy to provide at the moment, as GM potato cultivation is more or less absent from EU agriculture [recently ensured by the withdrawal of the authorisation of Amflora] and extensive product traceability is available within the sector.

3.3.3 Non-GM crops as a preset end goal

The third discourse 'non-GM crops as a preset end goal' is motivated from an agro-ecological perspective on agriculture (Wezel et al. 2011). GM crops are frowned upon because they are believed to reinforce a globalised and input-dependent EU agriculture while preventing a presumed necessary transition towards more sustainable, locally focused agricultural practices. GM crops are framed as an ecological and social hazard that hinders sustainable farming while undermining freedom of choice by farmers and consumers. Non-GM EU agriculture is a preset end goal and considered as perfectly feasible provided that some adaptations are made, such as a decreased level of meat consumption. EU agriculture is considered to be sufficiently powerful to import strict non-GM raw materials. Science is perceived as being inherently limited and unable to provide conclusive proof that GM crops are safe in terms of the environment and public health. In addition, the ethical and socio-economic impacts of GM crops are regarded as equally important. The EU GM crop legislation must therefore implement a strict non-GM crop regime in the EU that excludes all GM crop applications. Table 3.4 illustrates how each stakeholder group advocates, opposes, or denies the third discourse.

Agricultural biotech industry	"The whole approval system in the EU is riddled with politics and Member States in particular use science to hide the politics."
Compound feed industry	"By definition we were not against it [non-GM compound feed], not at all. But today we have a number of serious, insurmountable practical problems. And they are fourfold: availability [of non-GM raw materials], logistic restrictions, low level presence contamination [in hard identity preserved raw materials], and price [of non-GM raw materials, as compared to GM raw materials]."
Food manufacturing industry	"GM is not a goal in itself. It is just a means."
Food marketing industry	"We are afraid that organic agriculture will disappear and then you cannot speak about freedom of choice anymore."
Potato industry	"We respond to our customers' demand, no GMO in the company. We want to be open to it [GM varieties], but only if retail and fast-food are willing to work with it. Only then can we take a step towards using it, but not at this moment. It is too early."
Organic farming sector	"The less [GM crops] present at the moment, the better and the easier the chance for organic to develop."

Table 3.4. Discourse 3 'Non-GM crops as a preset end goal'. This table illustrates how each stakeholder group advocates, opposes, or denies the third discourse. The bold box indicates the stakeholder group which strongly advocates this discourse.

Organic farming sector

This discourse is strongly advocated by NGOs and the organic farming sector, resulting in a discourse coalition that is also a strategic coalition, as the organic farming sector largely sides with the anti-GM campaign governed by NGOs (Apel 2010). As such, the organic farming sector can focus its own communication on highlighting the added value of organic products while NGOs take the lead in the anti-GM communication:

> "GMO is just one item amongst all the other aspects of ecological foods. We follow it, so that the consumer hears a critical noise and so that GMOs are not considered as obvious. But we mainly have a responsive mode of operating" (Organic farming association).

3.4 Discussion

So far, this chapter has analysed which discourses influence agribusiness companies' decisions about GMI commercialisation on the EU market in the context of the apparent non-GM crop regime in the EU. Three distinctive discourses were identified, which have an influence on the business decision-making processes of several industry sectors under study. Altogether, the business decision-making processes of actors in the agricultural biotech and compound feed industries were predominantly determined by the first discourse. The GM business policy of food

manufacturers was strongly instigated by the second discourse, where the non-GM sales strategy is perceived as an own responsibility, as long as the majority of EU consumers reject GMIs. However, multiple food manufacturers have also mentioned that some GMIs might become a by-default reality on the EU market if no specific measures are taken (according to discourse 1).

Discourse 2 also strongly determines retailers' GM business policy. However, on a firm-specific basis, a retailer's GM business policy might also be influenced by the first discourse, as a few retailers expected that several GMIs might become a by-default reality on the EU market if no measures are taken to prevent this. This is contrary to other retailers who were totally resigned to the future possibilities of a completely non-GM EU agriculture (see also Chapter 4). A minority of retailers also disapproved of GM crop applications from an agricultural perspective, or mentioned the potential hazardous effects of GM crops on the ecosystem, animal or human health, therefore aligning with the third discourse on a firm-specific basis (Chapter 4).

In the potato industry, the GM business policy was strongly determined by the second discourse. Trade problems with GM potatoes were perceived as rather unlikely, so these stakeholders counter the first discourse from their own industry's perspective. On the EU fresh potato market, they regard EU agriculture as being sufficiently powerful to impose a non-GM criterion on its supplying countries, if necessary. Trade in potato varieties for industrial processing has greatly increased in recent years, especially imports (VIB 2014), but the EU is expected to be able to freely determine its own preferred (non) GM-standard.

Finally, the business policy of the organic farming sector is determined by the third discourse. However, they also partly advocate the second discourse, as GMI commercialisation in organic products is perceived as a black-or-white marketing choice, where compliance with demand by organic consumers is vital. The sector is convinced that organic farming will persist in any GM crop regime, but they fear potential reductions in customers, increased production costs, and loss of their image in the event of GM crop trace contaminated harvests, if GM crops were to be cultivated on a larger scale in the EU. Hence, the main difference from the second discourse is the fact that GMIs are perceived here as not being an option at all.

The EU non-GM crop regime is a wicked problem

Combining our findings in the discourse analysis with the typical characteristics of a wicked problem leads us to classify the current non-GM crop regime in the EU as a wicked problem (Batie 2008; Dentoni et al. 2012) (see also Chapter 2 for the characterisation of a wicked problem):

(1) *Wicked problems are difficult to define clearly. They have no clear problem statement, because the nature and the extent of the problem are not clear.* The problem statement for stakeholders that advocate the first discourse - GMIs as an agricultural payoff - relates to the potential competitive disadvantage of not implementing GM crop applications in EU agriculture. The second discourse - GMIs as a marketing threat - identifies the potential commercial risks associated with GMI commercialisation on the EU consumer market as the problem. The third discourse - non-GM crops as a preset end goal - sees the GM crops themselves as a problem in posing an ecological and social threat. This discourse analysis therefore enables us to illustrate the contestation of the problem definition for GM crops, their applications and the associated EU situation (Hajer and Versteeg 2005).

(2) *Wicked problems have multilevel actor involvement with many interdependencies. There are multiple conflicting goals at stake that all emphasise different risks.* The goal formation in the first discourse focuses on incorporating the consequences of a globalised EU agriculture. The second discourse aims to generate a predictable and coherent sales strategy, while the third discourse tries to prevent the cultivation of GM crops in the EU by all means. Also the risk-emphasis shifts in each discourse. Namely, the first discourse emphasises the potential competitive disadvantage of not implementing GM crop applications in EU agriculture (especially GM imports). The second discourse stresses the potential commercial risks, as EU consumers are perceived to be averse to GMIs. The third discourse emphasises the potential ecological and social risks of GM crops and their applications.

(3) *Wicked problems are often multi-causal, meaning that different stakeholders put forward different causes to define the problem.* In the first discourse, the EU political landscape is blamed for creating an unworkable business situation. Advocates of the second discourse mainly see a marketing threat in GMIs. Supporters of the third discourse charge GM crops themselves with reinforcing a globalised and input-dependent agricultural system.

(4) *Wicked problems have no clear solution. Effective solutions require coordinated action by a range of stakeholders and they involve changes at all levels of society. They are not the responsibility of a single organisation.* In the first discourse, actors prefer a solution that fits a globalised EU agriculture. Advocates of the second discourse prefer a solution where options for non-GM products remain available (at no higher prices). Supporters of the third discourse prefer a solution where all GM crops and their applications are simply banned from EU agriculture and the EU market.

(5) *Attempts to address a wicked problem often lead to unforeseen consequences. Solutions for tackling a wicked problem often create unforeseen side effects and introduce new problems.* A good example to illustrate unforeseen consequences of measures applied to this wicked

problem is Regulation (EC) No 1830/2003. This Regulation requires GMI labelling (above a threshold of 0.9%) and it was implemented as a political attempt to comply with the objective of consumer organisations and NGOs to ensure consumer choice, while still ensuring practicability, as a zero-tolerance threshold level for GM crop traces was thought to be unworkable (see also Chapter 1). However, for the food industries, which support the second discourse, this attempt to establish a middle ground places them in a difficult position, because it prevents them from openly questioning the safety of GM crops (as many of their products might contain GM crop traces below 0.9%). Likewise, this Regulation exempts GM labelling of animal products that are produced from GM-fed animals. In practice, this exemption has led to unfair competition between products derived from GM-fed and non-GM fed animals. This Regulation has therefore created a very difficult situation for (some) actors that support the first and second discourse.

(6) *Wicked problems are often unstable, as the available evidence and constraints to fully understand the problem are also evolving by themselves - which makes the problem even harder to solve.* Important dynamics in relation to the first and third discourses are, for example, the recent amendment to Directive (EC) 2001/18/EC which allows Member States to request an opt-out for (parts of) their national territory when the EU is authorising a new GM crop for cultivation. Also, the fact that Members of the European Commission are re-elected every five years illustrates the dynamic stability of this wicked problem, because this can have a significant influence on approving new GM crops for either cultivation, import and/or processing in the EU. For actors that support the second discourse, examples of the dynamic stability of this wicked problem are the recent GM-free labelling legislation for non-GM products in some Member States, while it is being prohibited in others (Gaugitsch and Heissenberger 2012). This partially changes 'their' problem at stake.

Based on these multiple criteria, the present EU non-GM crop regime (the lock-in) can be classified as a wicked problem. It is not the GM crops or GM foods themselves that constitute the wicked problem, but the accompanying regime that embeds the production, dissemination and use of this agricultural innovation within EU agriculture (Kemp et al. 1998). This means that the established practices within EU agriculture (including social norms, interests, rules and belief systems, etc.) are also part of the very problem definition of this lock-in (Schuitmaker 2012).

3.5 Conclusion

This chapter has defined multiple discourses that shape the discursive space for GM crop applications in the EU from an agribusiness perspective, emphasising the importance of observing

and modelling the perceptions, behaviour and attitudes of stakeholders involved in the EU lock-in for GM crop applications.

In summary, the chapter has analysed how several agricultural industry sectors make decisions about GMI commercialisation on the EU market in spite of the virtual non-GM crop regime. Three distinctive discourses were identified, which have an influence on this business decision-making process: (i) GMIs as an agricultural payoff; (ii) GMIs as a marketing threat; and (iii) non-GM crops as a preset end goal. These three discourses are not mutually exclusive, in the sense that they do have thematic congruence (see Chapter 4).

The three discourses were applied to explain the GM business policy of multiple agricultural industry sectors. By doing so, this research addresses an important remark in the paper of Arts and Buizer (2009), who argue that discourse analyses too often stick to the reconstruction of 'free floating' ideas and meaning, without answering the question 'so what?'. By linking the three identified discourses with how they influence the business decision-making process for several agricultural industry sectors on whether to include GMIs in products for the EU market, this chapter also defined how, and to what extent, the discourses actually influence social processes and outcomes (Arts and Buizer 2009).

The chapter has also shown that the accompanying regime that embeds GM crops within EU agriculture (the lock-in) is a wicked problem. This confirms that we can take the concept of 'wicked problems' as the theoretical lens for analysing our case study. The discourse analysis is a valuable analytical tool in this regard, because discourse influences action, and actions influence the success and content of the discourse (see the methodology Section 3.2). This enabled us to analyse actors' interpretations of the problem, as well as how these actors reproduce the lock-in within their own daily practices.

Managing a wicked problem is, however, the shared responsibility of multiple stakeholder groups, but this forced interdependency is also the stumbling block for dealing with a wicked problem, as the multiple stakeholders involved have conflicting ideas, concepts and categories through which they give meaning to GM crops and their applications. In this regard, agribusiness actors will have to shift their business-as-usual practices to deal with this wicked problem (Chapter 7).

This chapter has been adapted from: Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2014). The non-GM crop regime in the EU: How do Industries deal with this wicked problem?. NJAS-Wageningen Journal of Life Sciences, 70, 103-112.

CHAPTER 4.
THEMATIC CONGRUENCE IN DISCURSIVE BATTLE: INTRODUCING THE STRUCTURING ARENA

What if we try to fit into the same perspective?

CHAPTER 4.
THEMATIC CONGRUENCE IN DISCURSIVE BATTLE: INTRODUCING THE STRUCTURING ARENA

"Learning another language is not learning different words for the same thing, but learning another way to think about things." (Flora Lewis)

Chapter 3 has already discussed how actors in agribusiness give meaning to GM crops and the current lock-in, and how these perceptions can be linked to actors' strategic behaviour. In this chapter, we will specifically look for thematic congruence in the type of explanations and arguments that are put forward by these actors who support divergent discourses on GM crop applications.

Based on a conventional content analysis of our interviews with agribusiness actors, we introduce the concept of a 'structuring arena' (SA). This SA framework is a bottom-up defined analytical representation of thematic congruence that we observed in the types of tensions and influences that ground an agribusiness actor's overall interpretation of GM crops and the current lock-in within EU agriculture. The SA framework shows this thematic congruence along a two-dimensional grid that distinguishes internal and external influences from compelling and noncommittal influences. This chapter is therefore a further step in the analysis of how actors in agribusiness give meaning to GM crops and the current lock-in within EU agriculture (RQ3). Based on this SA framework, the chapter also explains, in more detail, gatekeepers' strategic behaviour towards GM-labelled food products on the EU market.

4.1 Introduction

Agribusiness actors try to be both competitive and socially accountable in their use, or rejection, of GM crops and their applications on the EU market (Sung and Hwang 2013). In this regard, Chapter 3 has already discussed how actors in agribusiness give meaning to GM crops and the current lock-in within EU agriculture, and how these perceptions can be linked to their strategic behaviour.

As these three discourses are divergent, the actors are involved in a 'discursive battle' that is played out on public stages (e.g. news, media), where discourse coalitions try to influence relevant audiences in order to obtain legitimacy and political, financial and public support for their view (Geels 2010; Inghelbrecht et al. 2014a). This notion on discourses explicitly incorporates conflict

and discord, and requires the identification of at least some thematic congruence in actors' argumentations if we want to turn the current debate into some form of dialogue. To take on this challenge, it is important to define elements that are commonly present in all these 'different talks' about (commercialising) GM crop applications within the sampled agribusiness population. The specific research questions in this chapter are therefore as follows:

(1) Can we identify thematic congruence in this discursive space for GM crop applications in EU agribusiness?

(2) How can this thematic congruence help to explain how food manufacturers and retailers explain and defend their GM business strategy for EU-marketed food products?

The following sections construct the structuring arena stepwise, based on a conventional content analysis of the 41 interviews with agribusiness actors (see also Chapter 3). This SA is therefore defined across multiple agricultural industry sectors that are formally or informally interrelated, representing *thematic congruence* in the explanation and argumentation of these diverse actors. Secondly, the analysis shows how food manufacturers and retailers (referred to as 'gatekeepers' in the food industry) perceive and experience this SA. It clusters their arguments, objectives, practices, and interests along the dimensions and axes of the SA framework to better explain gatekeepers' strategic behaviour towards GM-labelled products on the EU market.

4.2 Methodology

Data analysis: the structuring arena

The analysis was based on the same set of 41 interviews with agribusiness actors, where a code book of 68 bottom-up defined codes gave an initial structure to each interview in NVivo 9, as outlined in Chapter 3. With this as a starting point, a conventional content analysis was conducted to analyse congruence in the type of explanations that were put forward by actors who support divergent discourses on GM crop applications. This by focusing on the distribution of social values and concerns within the wider range of spoken communication, whilst answering the core question "why, and to what extent, does someone say what, to whom, and with what effect?" (Stemler 2001). We particularly focused on how agribusiness actors framed GM crop applications, their perceived outlook on the EU market, whose actions were closely watched, or copied, and why, and what type of arguments, reasons and assumptions were actually put forward by the actor when discussing GM crops and the EU situation for GM crops. In this analysis, the 68 themes were further analysed and grouped using inductive category development (Hsieh and Shannon 2005). This resulted in eleven categories of arguments based on how different themes were related and

linked (e.g. based on their concurrence, antecedents, or consequences). Accordingly, these emergent categories organise and group the themes into meaningful clusters, relating to (1) how an agribusiness actor values GM crops and their applications in terms of potential benefits and drawbacks; (2) the agribusiness actor's overall view on science, (3–4) his outlook on agriculture and whether GM crops were perceived as necessary in (future) EU agriculture, (5) whether GM crops and GMIs are regarded as imposed or rejectable in EU agriculture and/or agribusiness, (6) what the long-term expectations were, (7) who would become a victim if GM crops were applied more widely in EU agriculture or on the EU market, (8–9) the marketing and risk management perspectives on GM crop/GMI commercialisation, (10) the extent to which the GM issue was actually an agenda item for the agribusiness actor, and finally (11) the perceived or experienced effects of the EU GM crop legislation.

Thematically, these categories were further clustered into four overarching dimensions that will make up the structuring arena for GM crop applications from an agribusiness perspective, as explained in Section 4.3. This structuring arena is not congruent in the sense that it represents the ideologies, business models or interests that are common in the sampled agribusiness population. The structuring arena is only congruent in the sense of a *mutual representation* of certain categories of arguments or explanations. This means that during the construction of the SA framework we did not focus on the actual 'for or against' in relation to the argument (however important in the discourse analysis), but only on the topic of the explanation or argument. For example, it is not important whether an actor argues that science can or cannot, ever or never, prove the absolute safety of a GM crop, but only that different agribusiness actors make systematic reference in their argumentation to scientifically proven safety to interpret GM crops, the EU business environment, and the lock-in within EU agriculture.

These four dimensions were refined, revised, and triangulated to achieve a higher level of accuracy using multiple sources of secondary data collected between 2010 and 2014, such as: (i) legislative texts, press releases, scientific literature, company websites, and grey literature updates; (ii) regular updates from key individuals; and (iii) multiple rounds of feedback and discussion on international fora. Next, these four dimensions were positioned along a two-dimensional grid that differentiates internal from external influences, and compelling from noncommittal influences – in line with, and based on, the diffusion models for technological innovation that Sneddon et al. (2011) use to explain why technologies are rejected within an agricultural context when, at first sight, they appear to be efficient. This grid structure, which is detailed in Section 4.3, finalises the structuring arena, as we refer to it.

The data analysis: gatekeepers' perspective

To answer the second research question in this chapter, we have individually re-analysed the interviews with all the food manufacturers and retailers in terms of which specific arguments, practices, interests, etc., were put forward by the gatekeepers. Next, these were categorised along the dimensions and axes within the SA framework. This study design assumes that the mutual and conflicting interests and priorities that exist amongst multiple agribusiness actors will play a crucial role in how gatekeepers perceive the 'rules of the game' for including or excluding GM crops on the EU market. The study design also places emphasis on the role of perceptions and the role of interaction in the strategic behaviour of gatekeepers. An inherent drawback of this methodology might therefore be that it loses sight of individual differences between gatekeepers by focussing too much on 'the commons', and this methodology might also lose sight of the relative importance of the arguments put forward by the gatekeepers, by focussing too much on which arguments. However, as section 4.4 will explain, the overall advantage of our study design is that it enables us to define the key perceptual tensions and influences that determine gatekeepers' strategic behaviour on GMIs for EU marketed food products specifically in relation to the general background of gatekeepers' beliefs, perceptions and interactions.

4.3 The structuring arena

The structuring arena maps meaningful clusters in the type of explanations that ground agribusiness actors' overall interpretations of GM crops, their lock-in, and the EU business environment for these applications. These perceptions condition the actor's (strategic) behaviour towards GM crop applications.

The *actual* boundaries of the structuring arena are, of course, set by regulations – for example, by the formal EU GM crop legislation, official trade agreements or treaties - but within these boundaries the perceived freedom (or otherwise) to use or reject an authorised GM crop in EU agriculture or in a company's business plan, can be determined by widely diverse perceptions in terms of economic, environmental, ethical or social arguments. These different elements, which are commonly present in all these different talks about GM crops, are schematised in the SA framework.

As a starting point, we will discuss the four dimensions of the structuring arena in terms of their content, and show how they are interrelated. Then, we will discuss the innovation diffusion models that form the basis of the SA framework. We will then finalise the framework by

positioning the four dimensions along a two-dimensional grid structure which is present in these innovation diffusion models.

Four dimensions of the SA: an overview of their meaning and mutual relationships

Dimension 1 – value judgement on GM crop applications. This dimension clusters three essential types of tensions and influences. First, 'the science perspective' which represents the agribusiness actor's perception about the ability of science to prove the safety of GM crops, both in environmental terms and in relation to human and animal health. This science perspective also reflects whether the availability of (unbiased) evidence on safety is currently considered to be sufficient. Secondly, this dimension includes an 'agricultural outlook perspective'. This perspective covers the agribusiness actor's overall view on agriculture. If GM crops are compatible with the actor's agricultural ideals, then agreement on the commercialisation of GM crops and their applications is more likely (for example with internalised agro-industrial actor standards). This perspective also covers whether GM crop applications are regarded as absolutely necessary, unnecessary, or only optional in EU agriculture. When GM crops, or their applications, are perceived as necessary for the agricultural capacity or resilience of EU agriculture then they become a business interest, or a reality with which the agribusiness actor will deal, whereas otherwise the technology must suit the actor. Thirdly, this dimension includes the agribusiness actor's overall 'value assessment of GM crop applications' in terms of potential benefits, drawbacks and risks, and how GM crop applications are scored with respect to alternative business opportunities.

Dimension 2 – profit-maximisation. This dimension represents the agribusiness actor's interpretation of the economic task environment in relation to GM crops. It incorporates marketing considerations and the risk management perspective. It clusters arguments about revenue management and supply-chain focus, as well as on perceived penalties in case of product failure and the proposed solutions to prevent such failure.

Dimension 3 – agricultural market power. This dimension represents how an actor characterises both the GM and non-GM agricultural markets. When GM crops, or their applications, are regarded or experienced as 'imposed' on EU agriculture or the agribusiness, agribusiness actors are more likely to allow, or commercialise, this externalised 'by-default' reality. This contrasts with a scenario where it is considered perfectly feasible to preserve a completely GM-free EU agriculture (with GM-free defined according to the current EU labelling standards; see also Chapter 1).

Dimension 4 – political power. This dimension includes an actor's perspective on, and experience with, the current EU GM crop legislation (in many diverse ways), such as experiences with Directive 2001/18/EC on deliberate release into the environment, or Regulation (EC) No 1829/2003 on the import of raw materials and their processing in food or feed applications.

No strict relationships can be drawn between these four dimensions, as the relative importance of each dimension differs according to which stakeholder, or stakeholder groups, is being analysed. Yet, several interdependencies can be defined. For example:

- The agricultural outlook perspective (in the value judgement dimension) influences the agricultural market power dimension, and vice versa. For example, when agriculture is presumed to be inherently globalised, then GM crop developments outside the EU will most probably influence the agribusiness actor's assessment on whether a completely non-GM identity-preserved EU agriculture is actually feasible. Conversely, when GM crops are experienced as being 'imposed' on EU agriculture – for instance by pressures from outside the EU, such as a WTO conflict or insufficient availability of certain non-GM certified raw materials – then these external pressures and the resulting 'GM by-default' sentiment can overrule the influence of the outlook on agriculture *per se*.
- Also, the political and agricultural market power dimensions have a mutual relationship, as the EU GM crop legislation determines the number of authorised GM crops, either for import, processing or cultivation in the EU. The longer these authorisations take, the higher the likelihood of importing raw materials that are contaminated with traces of GM crops that are not (yet) EU-authorised – simply because GM crop implementations occur much faster in, for example, the USA, Brazil, China and Argentina (James 2014) - and this can decrease the availability of raw materials (part of the agricultural market power dimension).
- Conversely, the agricultural market power dimension can also influence the political power dimension, as exemplified by Regulation (EU) No 619/2011. This Regulation sets a legal tolerance level of 0.1% (instead of zero-tolerance) for GM crop traces in imported raw materials that are processed in feed applications but derived from GM crops for which authorisation in the EU is pending, or for which EU authorisation has expired. This Regulation was a political measure to guarantee access by the European feed industry to several imported raw materials (see also Chapter 1). Hence, the political environment was adapted because of the constraints experienced in the agricultural market power dimension.

Innovation diffusion models as basis of the SA framework

Here, we will discuss the innovation diffusion models that form the basis of the SA framework

(which we finalise in the next section). These diffusion models explain why, in an ambiguous agricultural context, seemingly inefficient technologies are sometimes adopted, while more efficient ones are rejected. They explain that a company does not solely maximise profit through better technology performance or increased production efficiency, but that profitability can also be based on compliance with the social norm or by simple imitation behaviour. These perspectives therefore highlight "the dynamic, uneven, 'irrational' and potentially 'inefficient' nature of the diffusion of agricultural technologies" (Sneddon et al. 2011 pg. 468).

They are particularly relevant in relation to our case study, as the genetic modification of crops is, in theory, a promising technology that can increase overall agricultural productivity and efficiency (Brookes and Barfoot 2013; Mannion and Morse 2013; Klümper and Qaim 2014). However, in practice, many agribusiness companies (including gatekeepers) exclude the use of GM crops within EU agriculture or on the EU market. There are four perspectives in the diffusion models, which are the efficient-choice perspective, the fad perspective, the fashion perspective and the forced-selection perspective (Abrahamson 1991; Sneddon et al. 2011). Each perspective has different characteristics in terms of whether or not actors outside their own group have an influence on the potential technology adopter; and whether or not the decision of the potential technology adopter is influenced by imitation behaviour. In our use of these models, we will re-categorise each perspective along a two-dimensional grid with the first axis discerning whether or not actors outside their own group have an influence on the potential technology adopter (referred to as internal or external influence). The second axis differentiates whether or not an influence is experienced as binding in the decision of the potential adopter (referred to as compelling or noncommittal influence) (Figure 4.1).

The *efficient-choice perspective* assumes that an actor can (and will) make an independent and strict rational decision when rejecting a new technology, based on the technology's inefficiency and/or inability to overcome existing performance gaps. This perspective assumes that there is unbiased and unambiguous information available about the efficiency of the innovation (Sneddon et al. 2011) and presupposes a strict internal noncommittal decision-making process (Figure 4.1, top left). The efficient-choice perspective, however, has an inherent pro-innovation bias because once proven efficient, it assumes that any new technology will always be implemented.

The *fad perspective* presumes that a potential technology adopter does not make an isolated decision when rejecting an agricultural technology. Instead they mimic the behaviour of other non-adopters within a group (e.g. retailers). Faddish imitation is noncommittal, but the decision is not made entirely within the company, as external factors from within the sector exert an

influence. Nevertheless, we have also positioned this diffusion perspective at the top left in the framework, but noting that 'internal' here refers to a more sectoral level instead of 'strictly within the company' as in the efficient-choice perspective (Figure 4.1, top left).

The *fashion perspective* assumes that the potential technology adopter imitates the non-adopting behaviour of other influential individuals or organisations outside a group, such as technology providers, consultancy agencies and the media. Hence, this perspective mainly focuses on which organisation(s) they should imitate. Fashion diffusion patterns are mainly a consequence of 'fashion setters' who inspire members of the social system to trust their technology choice (Sneddon et al. 2011). This perspective has a non-binding character, because not all firms will respond in the same way to, for example, activist-contested practices (Waldron et al. 2013). These external, but noncommittal, characteristics position fashion imitation at the top right of the framework (Figure 4.1).

Faddish and fashion imitation are not necessarily the best business strategies to achieve efficiency and to increase performance, but they can be economically efficient strategies as they strengthen the corporate image to appear innovative, ethically responsible or trustworthy, for example. The systematic rejection of an innovation by the majority of actors, in this case GM crops, can also lead to the *institutionalisation* of this behaviour, which silently hinders self-evaluation (Swinnen and Vandemoortele 2010). Consequently, these companies act slowly in response to new information (Lieberman and Asaba 2006) and the institutionalisation of the GM business strategy itself becomes an internal compelling factor in the company's decision-making process (Figure 4.1, bottom left). Also, new entrants are likely to adopt the rejection behaviour without any further reconsideration. In this regard, institutionalisation has an external compelling character (Figure 4.1, bottom right).

The *forced-selection perspective* suggests that potential technology adopters are forced to adopt or reject an innovation by influential individuals or organisations from outside their own group who have the power and control to dictate, such as government bodies or sometimes trade unions (Abrahamson 1991; Sneddon et al. 2011). Of course, the extent and duration of the policy intervention, the market structure, and the type of technology will determine the overall impact of the political intervention (Feder and Umali 1993). However, overall, this perspective has an external compelling character and is therefore positioned at the bottom right in the framework (Figure 4.1).

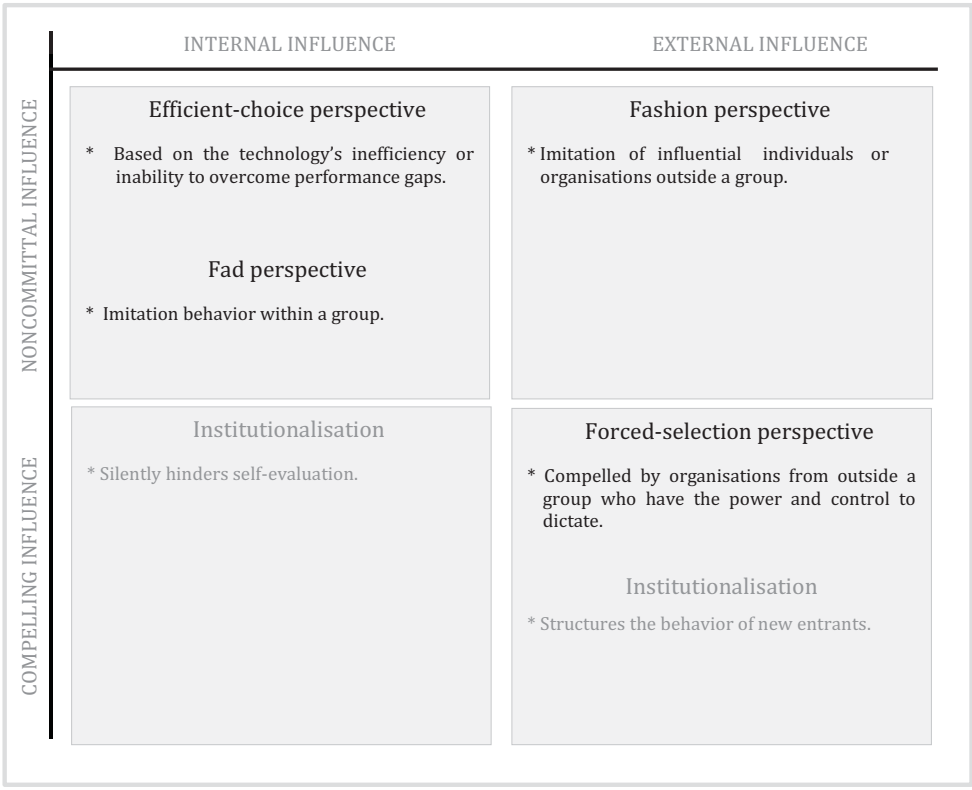


Figure 4.1. The innovation diffusion models as a basis of the SA framework.

The SA as a conceptual framework

The four dimensions that cluster arguments and reasoning on GM crop applications can also be classified according to this two-dimensional grid, which distinguishes internal and external influences (Axis 1), from compelling and noncommittal influences (Axis 2). Positioning the four dimensions on this grid will finalise the SA framework.

The *value judgement dimension* is represented in the SA framework along a threefold comprising the actor's science perspective, agricultural outlook and value assessment of GM crop applications. Both the value assessment and the actor's agricultural outlook have to comply with the actor's overall corporate identity, because otherwise the actor's integrity is at stake. This means that the corporate identity is an internal compelling influence that positions the value assessment of GM crops and the actor's agricultural outlook in the bottom left of the SA framework (Figure 4.2). We categorise the science perspective as an external compelling influence, because none of the agribusiness actors considered it their responsibility, or their responsibility alone, to

define the overall safety of a GM crop. A positive scientific safety assessment is certainly a standard requirement before agribusiness actors want to commercialise GM crops. However, as this is a prerequisite for EU authorisation of a GM crop, it occurs prior to commercialisation anyway (Figure 4.2, bottom right). So, the responsibility for safety in the science perspective is mainly averted, but this does not mean that the safety of GM crops is uniformly accepted or not debated.

The *profit-maximisation dimension* crosses all parts of the framework, as profitability of GM crops was considered to be the result either of increased competitiveness, or of complying with the sectoral and/or social norms. This dimension crosses the top left and top right sections of the framework, because imitation behaviour is an important parameter in the actor's interpretation of the economic task environment (either within or outside a group, respectively). This dimension also crosses the bottom left part of the SA framework, because when an agribusiness actor strongly markets its corporate identity (e.g. natural products, lowest price, environmental safety) then the overall identity exerts a strong internal compelling force on his interpretation of economic possibilities. The EU GM crop legislation – with its mandatory labelling and identity preservation requirements – forms an external compelling force for the profit-maximisation dimension, because it directly determines the standard safety and business requirements for the approval or commercialisation of GM crop applications in the EU environment. Therefore, the profit-maximisation dimension crosses the bottom right section of the framework (Figure 4.2).

When GM crop applications are perceived as a 'by-default' reality in EU agriculture and on the EU market, the *agricultural market power dimension* has an external compelling influence on the agribusiness actor's perceived SA for GM crop applications in the EU (Figure 4.2, bottom right). Otherwise, when GM crop applications are perceived as being rejectable in EU agriculture and/or in agribusiness, the actor's perceived SA is determined either by faddish imitation, fashion mimicking and/or by prioritising the corporate identity standards (Figure 4.2, top left, top right, bottom left respectively).

The political power dimension has an external compelling influence on the agribusiness actor's perceptions of GM crop applications in the EU market (Figure 4.2, bottom right). That is because this legislation determines the safety, production and commercialisation conditions for GM crops in terms of labelling, safety-requirements and identity preservation, amongst others. These are compelling external forces that have a direct influence on the perceived SA for GM crop applications on the EU market.

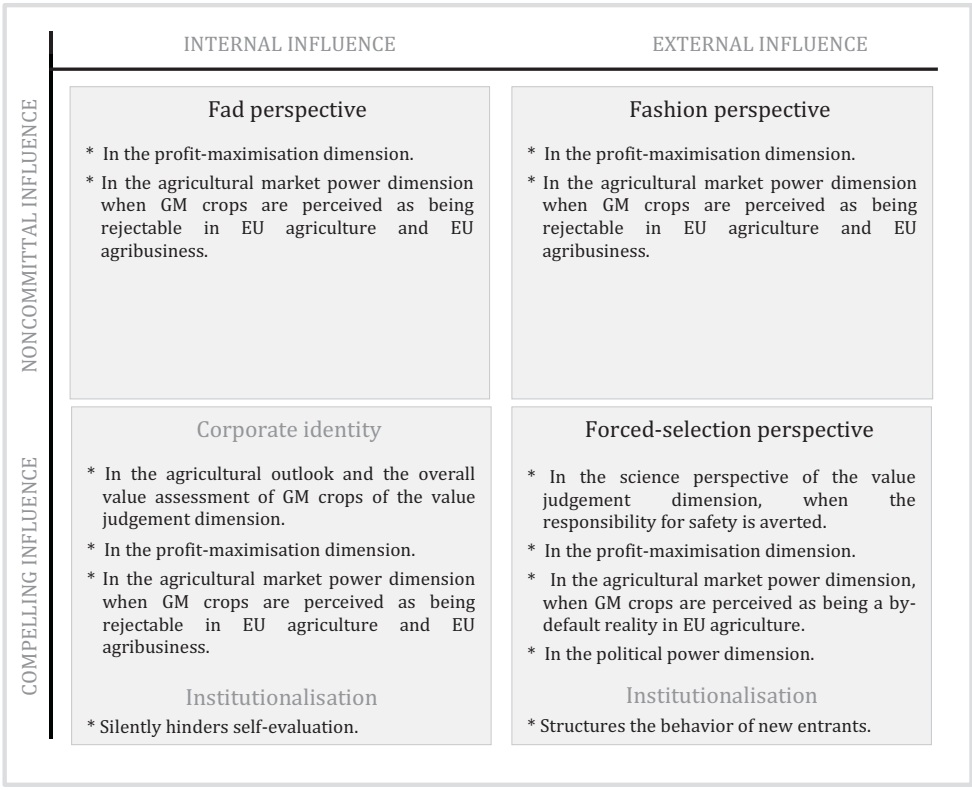


Figure 4.2. The structuring arena for GM crop applications in the EU. The framework represents the perceptual tensions and influences underlying an agribusiness actor's overall interpretation of GM crops, their lock-in, and the EU business environment for these applications. It is a two-dimensional grid that distinguishes internal and external influences, from compelling and non-committal influences. It is constructed through the representativeness of categories in the coding of the interview data and through the eyes of the agribusiness actors involved.

4.4 Explaining gatekeepers' strategies based on the SA framework

The future prospects of GM crop applications on the EU market will, to some extent, depend on how food manufacturers and retailers in the supply chain perceive the society-specific, political-economic pressures in the EU business environment. That is because, as several authors argue, these downstream actors behave as 'gatekeepers' who control the supply chain (Bett et al. 2013; Knight et al. 2008): "food industry and retail corporations, in particular, have become key players in the governance of the global food system through the creation of governance institutions such as private standards, corporate social responsibility initiatives and public–private or private–private partnerships" (Fuchs et al. 2011 pg. 353). This high level of control over the supply chain also makes gatekeepers directly visible to consumers and therefore more vulnerable to social

influences. Given that gatekeepers have to be both competitive and socially accountable in their GM business strategy for the EU market, this second part of the analysis will provide an in-depth analysis of how gatekeepers explain and defend the virtual exclusion of GMIs from EU-marketed food products based on the SA framework.

The arguments, objectives, and interests that gatekeepers put forward were clustered according to the dimensions and axes of the SA framework. One particular value of this methodology is that by starting from this meta-view to define the congruent structuring arena (stage one of the analysis), gatekeepers' arguments are clustered in a manner that provides a better understanding of the general background to their beliefs, perceptions and actions.

The dimensions in the SA as perceived by food manufacturers and retailers

Dimension 1 – value judgement of GM crop applications. Food manufacturers and retailers have an open attitude towards scientific innovation and they define science as perfectly able to prove the environmental and public health safety of GM crop applications. However, they do not see it as their responsibility to prove this scientific safety:

> "We must be careful not to take over the role of the government. Their role is to define what is safe and what is healthy. Our role can be defined as follows: when a consumer does not want to follow the government's advice, we must still offer him freedom of choice within the regulatory framework" (National retail federation).

However, several retailers have mentioned the potentially hazardous impacts of GM crops on human health, the environment and/or in socio-economic terms, whilst a few retailers also disapproved of the currently available scientific evidence on safety as being inadequate or biased. Strikingly, these arguments were systematically neutralised when more detail was requested. When the safety of GM crops is scientifically proven [which for them also implies that this proof is no longer publicly contested], retailers and food manufacturers expect, at best, health benefits and environmental advantages from GM products. Strictly economic benefits were rarely mentioned as a factor for initiating the sale of GM-labelled products on markets in the EU (especially not by retailers):

> "Let me put it simply; although the question has not been posed. If you would ask whether we would make the choice today to sell a product 10% cheaper but with GMOs, we will not do that. So offering us the possibility today to do it and to reduce the price, that is not the choice that we will make" (Retailer d).

GM crop applications were mainly highlighted as an option that no-one currently awaits:

> "GM is not a goal in itself, it is nothing more than a tool" (National food manufacturers' federation).

GM crops were never evaluated as being a necessity for a productive (future) EU agriculture. Retailers and food manufacturers experience these crops as optional but not as obligatory in agriculture or in the business plan. However, a handful of retailers did criticise GM crops for reinforcing the globalisation of trade in food ingredients, or for negatively impacting on locally embedded farming systems:

> "We worry about the impact [of GM crops] on local agriculture. It will be destroyed if you want to organise an import that is much cheaper"(Retailer b).

Dimension 2 – profit-maximisation. Food manufacturers and retailers attempt to satisfy all their prospective clients and they seek the most uniform marketing strategy (across Europe if possible). Therefore:

> "As long as European consumers are reluctant about the use of GM crops in food production, we have no intention of processing them" (Manufacturer a).

Due to commercial fear, the food companies are currently delaying their first move towards open GMI marketing within their own brand(s) until the overall EU consumer perception is more positive. The current marketing strategy seems to be the most univocal, coherent and predictable sales strategy. Yet, none of these companies have themselves examined, in much detail, the perceptions of their clientele towards GM-labelled products:

> "We shall not say we have done any special research about this [own consumer analysis about the presence of GMIs in their marketed products], but we do see that the consumer is not open to such products" (Manufacturer b).

Credibility and trustworthiness towards their clientele are further important incentives to openly exclude GMIs from their products. Although a virtually non-GMI sales strategy may not be the most efficient strategy in terms of performance, it strengthens the corporate image of being trustworthy and able to take responsibility. For several companies, the current GM business strategy has taken its toll. Food manufacturers experience the adoption of a virtually non-GMI sales strategy merely as 'damage control'. Whether it is also a burden, depends on the product portfolio of the manufacturer:

> "Despite having almost all kinds of products in our portfolio, we are actually less affected by GM crops. This might sound strange, but some companies are affected much more severely than us,

because they are in a very specific branch, such as producing cereals" (Manufacturer a).

Conversely, most retailers experience the non-GMI product criterion as equivalent to other product requirements, although a few retailers did mention an extra (quoted unfair) production cost for non-GM products. Yet in practice, every retailer adopts the polluter pays principle and they mainly spot-check their products for GM crop trace contamination above the permitted regulatory threshold levels,

"We do some controls, but they are limited. We do not check international brands, but mainly products from our own generic brand" (Retailer a).

Dimension 3 – agricultural market power. Food manufacturers and retailers differed in their opinion on whether a completely, certified non-GM EU agriculture is possible in terms of future prospects. All manufacturers and several retailers reported many pressures from outside the EU which may, perhaps in the longer term, threaten the preservation of a completely non-GM EU agriculture. For example,

"China asks no questions. That is one of the biggest problems, because if Europe is too difficult they have other customers who are not that difficult. So why would they still choose Europe?" (Retailer b).

This group stressed the need for practical solutions to avoid a GM-by-default future scenario in the EU. In contrast, several supermarkets evaluated a completely non-GM EU agriculture as perfectly feasible, as the potential problems are regarded as self-solvable:

"The market will initiate a counter reaction towards more non-GM crop cultivation'' (Retailer c) or "As non-GM progresses to become a niche product, we expect an increased tolerance for GM crop traces in non-GM material" (National retail federation).

Dimension 4 – political power. Every food company had its own remarks and criticism on the EU GM crop legislation, but most of the proposed adaptations aimed to secure non-GM product sales for the EU market. Almost systematically, Regulation (EC) Nos. 1829/2003 and 1830/2003 were criticised for generating the most difficult position, as all the exemptions to GM-labelling create the uncomfortable position of always indirectly processing or selling GMIs in the company – which may negatively impact on the company's overall corporate image.

Why gatekeepers virtually exclude GMIs from EU-marketed food products

Retailers have almost systematically framed their GM business strategy as a part of their overall corporate policy on sustainable and/or healthy food products, whereas food manufacturers have

a more self-contained GM business strategy. However, both emphasise corporate values, such as credibility and trustworthiness, in their justification for the virtual exclusion of GMIs from EU-marketed food products. These values therefore have a strong *internal compelling force* on how gatekeepers assess GM-labelled food products on the EU market (Figure 4.3, bottom left).

However, the current EU labelling definition of 'GM' forms a direct threat to these corporate values, as no food manufacturer or retailer can actually claim a true GM-free identity because, to some extent, GM crop traces are always theoretically present in their products:

> "Just one organisation, such as an NGO, must claim that there are GMIs in our products and that will influence public opinion. But it is the legislation which is not sound. So if you try to create an image of working GM-free, then you are under fire [. . .] You cannot claim that GM crops are an environmental threat, because then you bring yourself down with your dairy products that you do sell. It is the whole duality that we are confronted with. It is impossible for us to be consistent over the entire product line in the GM story" (National retail federation).

Nevertheless, the labelling of, for example, GM-fed animal-derived food products is not necessarily favoured because then many products that are now sold would require labelling and that could potentially harm the overall company image. The current EU labelling definition is also the reason why many, but definitely not all, gatekeepers are not interested in the use of a GM-free label per se. However, several of these non-interested actors emphasised that they would mimic this marketing behaviour when competitors from either inside or outside their own group launch it. This exemplifies the respective contribution of faddish and fashion imitation to the virtual exclusion of GMIs in EU-marketed food products (Figure 4.3, top left and top right).

Faddish imitation puts a strong *internal noncommittal influence* on all gatekeepers' GM business strategies for the EU market (Figure 4.3, top left). It is actually a sound strategy, because a collective non-GMI decision generates interchangeable raw material supplies at the lowest price and free from competition (Kalaitzandonakes and Bijman 2003).

Fashion imitation was a strong *external noncommittal influence* on these food companies (and thus for the strategic behaviour of these actors), particularly because the gatekeepers considered NGOs to be 'superbranding actors' in terms of non-GMI-related marketing (Figure 4.3, top right), "given the rather low profit margins of both food processing and retailing, firms can ill afford the adverse publicity associated with NGO campaigns. In contrast, they are happy to have the support – and free advertising – that NGOs can bring" (Busch 2011 pg. 345). Retailers mimicked the GM-criticism of NGOs even more than food manufacturers, pointing to an even higher level of private

governance being exerted on retailers in relation to GMI commercialisation (determinant of their strategic choice to virtually exclude them).

Overall, both faddish and fashion imitation were strong strategic determinants in gatekeepers' GM business strategy in order to maximise profits with social compliance (Figure 4.3, top left and top right). Accordingly, the profit-maximisation goals of gatekeepers in relation to GMIs are, at present, not strongly related to the technological efficiency of GM crops, but directly to market sales. This also explains why the efficient-choice perspective cannot explain why the gatekeepers virtually reject GMIs,

> "We depend completely on our customers. If the consumer does not want it anymore, then it is over" (Manufacturer d).

Both faddish and fashion imitation behaviour were actually 'rivalry-based', meaning that firms imitate others to maintain competitive parity or limit rivalry (Lieberman and Asaba 2006). Firms can also mimic other firms because they are supposed to possess superior information. This 'information-based' imitation behaviour (Lieberman and Asaba 2006) could not be identified in our analysis as the companies sampled in the food industry had similar information access (due to similar company size and accessibility to resources). Hence, for smaller food manufacturers or retailers information-based imitation behaviour can also be an incentive to openly reject GMIs in EU-marketed food products.

Gatekeepers' perceived or experienced *external compelling tensions* that affect their strategic behaviour are exerted by the political power dimension and the agricultural market power dimension (in some cases), which both act through 'forced-selection' (Figure 4.3, bottom right). For example, Regulations (EC) Nos. 1829/2003 and 1830/2003 have a forced selection on gatekeepers as it obligates traceability (especially in a commodity supply chain) and GM labelling directly exposes the gatekeepers' chosen GM strategy. This political forced-selection pressure per se is neither in favour of, nor against, GM crops or their applications, but in practice it prevents the sale of GM-labelled products alongside non-GM labelled products on EU supermarket shelves (Gruère et al. 2008; Figure 4.3, bottom right). The gatekeepers' current GM food strategy can thus be interpreted as a means to reduce the perceived business uncertainty of commercialising GMIs on the EU market into a more predictable, black-and-white choice decision that simultaneously protects the *whole* brand or store image (Kalaitzandonakes and Bijman 2003; Figure 4.3, bottom left).

The agricultural market power dimension can also exert external compelling forced-selection on gatekeepers' strategic behaviour for GM food products on the EU market. This occurs when

gatekeepers perceive GM crop applications as a 'by-default' reality in EU agriculture or on the EU market (perhaps in the long term). This GM-by-default sentiment was experienced by all food manufacturers and by several retailers, if no measures were taken (Figure 4.3, bottom right). Conversely, several retailers considered that a completely GM-free EU agriculture would be perfectly feasible, in which case GM crop applications were simply optional (not forced) and judged according to the retailer's corporate identity and/or faddish or fashion imitation behaviour.

Gatekeepers were often not very interested in reconsidering their GM business strategy for the EU market because, for example,

> 'We took a decision and that is clear. We do not want to change our policy every month. GMOs are a product that we do not want to sell, so why should I ask it to my customers every month?' (Retailer c) or 'You apply a conservative strategy, preserving the present strategy of guaranteeing 100% that it is not present, also for the markets which are positive' (Food manufacturer c).

In this sense, the institutionalisation of this strategy becomes an internal compelling determinant of the gatekeepers' strategic behaviour (Figure 4.3, bottom left); except for food manufacturers where the availability of certain non-GMIs was difficult or limited, in which case GMIs were actually a business agenda item.

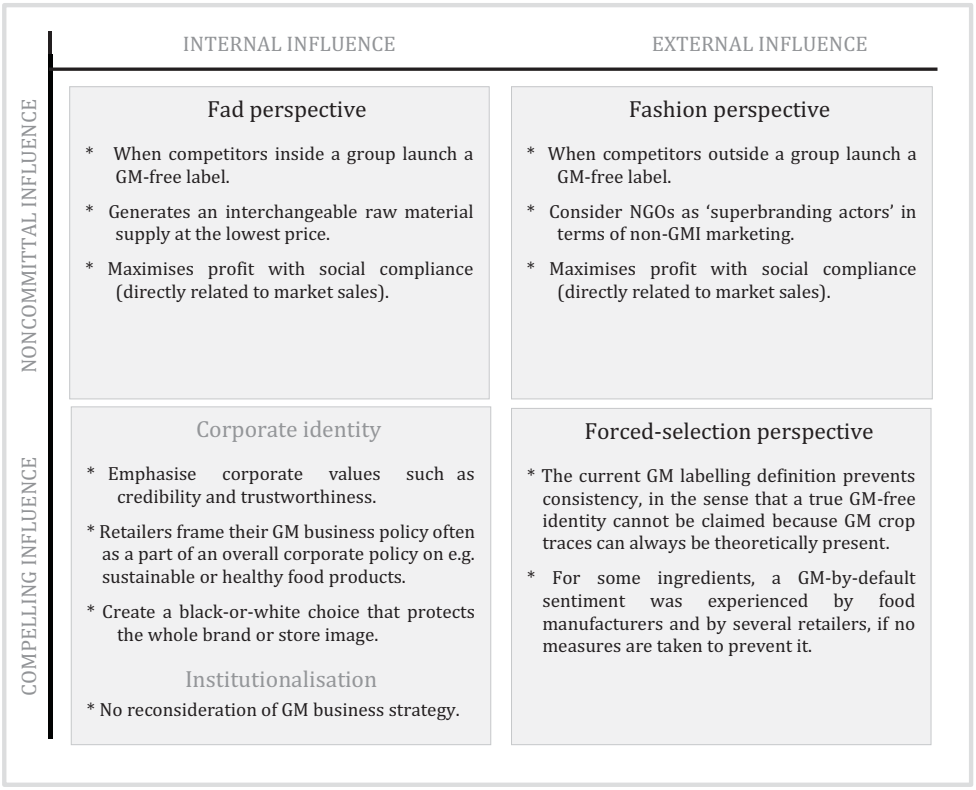


Figure 4.3. Gatekeepers' SA framework. This figure illustrates how food manufacturers and retailers account for their GM business strategy on the EU food market based on the SA framework. The framework is a two-dimensional grid that differentiates internal and external influence, from compelling and non-committal influence.

4.5 Conclusion

This chapter has introduced the concept of a structuring arena, as a means to define thematic congruence in the argumentation of diverse actors in agribusiness who support divergent discourses on GM crop applications (see Chapter 3). The analysis has defined thematic congruence in the type of influences that explain an agribusiness actor's overall interpretation of GM crops, the lock-in, and the EU business environment surrounding these applications. This chapter has also defined gatekeepers' strategic behaviour on GM-labelled food products for the EU market in more detail, thereby linking perceptions to strategic behaviour once again.

The SA analysis highlights an important barrier to re-framing the problem statements of competing parties, because actors in agribusiness have a different moral or epistemic basis for

looking at different aspects of the problem. For example, the SA analysis highlights incompatibilities within the agricultural market power dimension, as arguments in this dimension can either have an epistemic basis or a moral basis, thereby focusing respectively on whether a non-GM agriculture *can* be realised ('true' or 'false') or carries instead a moral claim that it is *desirable* (Arts and Buizer 2009).

The SA framework further shows that several elements, such as corporate identity and imitation behaviour, also influence the sociotechnical practices that reproduce the lock-in for GM crop applications within EU agriculture. These factors codetermine individual actor behaviour, but they are not institutionalised as regime elements and are, therefore, not a main focus in this dissertation. Accordingly, we will be able to provide an extensive, but not all-inclusive, characterisation of the lock-in in Chapter 7 (RQ1).

Finally, no overall conclusions can be drawn about how the SA analysis can help to characterise, complement, or structure an analysis of discursive space. That is because the SA framework is based upon the innovation diffusion models, which specifically model the reasons for rejection of what are, at first sight, efficient technologies within an agricultural context. The only extension that can be made in order to better characterise a discursive space in general, is perhaps the advice to look at influences as being either compelling or noncommittal, and coming from inside or outside an own group.

This chapter has been adapted from: Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2015). Explaining the present GM business strategy on the EU food market: The gatekeepers' perspective. New biotechnology, 32(1), 65-78.

CHAPTER 5.

FITTING THE NORM BUT MISSING A BREAKTHROUGH: LESSONS LEARNED FROM INTRODUCING GM CROPS IN EU AGRICULTURE

History has all the characteristics of a remembered one.

CHAPTER 5.

FITTING THE NORM BUT MISSING A BREAKTHROUGH: LESSONS LEARNED FROM INTRODUCING GM CROPS IN EU AGRICULTURE

"History cannot give us a program for future action, but it can give us a fuller understanding of ourselves and of our common humanity, so that we can better face the future." (Robert Penn Warren)

The chapter defines why apparently incremental innovations can still have a hard time breaking through (RQ4). Namely, agricultural biotechnology was introduced as an extension of industrial agriculture and a panacea for problems such as food security, malnutrition or environmental issues. It is therefore a logical assumption that GM crops would be seen as resources within EU agriculture. Yet today, the use of these crops is heavily contested, so how come that a technological innovation with an obvious 'structural fit' did not obtain broad legitimacy, and what can be learnt from that in terms of future technology development and the structures underlying agricultural systems?

The analytical framework applied in this analysis is the multi-level perspective (MLP) on transitions. It is used as a heuristic to position first generation GM crops (with improved agronomic traits) in relation to the dominant rules and resources within EU agriculture during the early stages of this innovation journey; describing the path dependency of GM crops and the co-evolution with societal developments.
An innovation journey gives a longitudinal perspective on the co-evolution of societal and technological developments, as a way to explain the social embedding of a new innovation specifically in relation to existing regime practices (Geels and Verhees 2011). Based on this analysis, we also illustrate how 'regime outsiders' used GM crops to revive or reinforce certain discourses that criticise institutionalised practices within EU agriculture. As a potential way forward, the paper analyses whether the niche protection functions that are typical for embedding radical innovations may also be relevant for successfully implementing incremental innovations. On this basis, the argument is made that apparently incremental innovations, such as GM crops, might also benefit from a specific 'niche'-type environment. Namely, it is important to go beyond a simple 'fit-and-conform' empowerment for incremental innovation which only considers that the innovation can become competitive in terms of conventional regime criteria.

Together, the chapter provides a better understanding of the sociotechnical practices in which GM crops are embedded, the rules and resources (i.e. the structure) within the EU agricultural regime,

and how these are interrelated. This chapter thus changes the actor perspective which is more central in Chapters 3 and 4, to a system perspective and by doing so it provides several aspects of the answer to the two overall objectives of this dissertation (RQ1 and RQ2).

5.1 Introduction

Agricultural biotechnology took off in the 1980s, in the spirit of overall technological modernisation and progress within EU agriculture (Geels and Verhees 2011; Roep et al. 2003). GM crop applications were introduced as a logical and even necessary extension of industrial agriculture and a panacea for a large number of problems. For example, GM crops were advertised to generate new practical solutions for producing enough food for a growing world population, while decreasing the costs of farming, keeping food prices low, eroding malnutrition, addressing environmental problems and chemical stress in agricultural productions, etc. (Burkhardt 1988, Buttel 1993, ISAAA 1991; Silva 1988, Vaeck et al. 1987).

This modern agricultural paradigm created incentives ('structural support') for explicit investment in chemical input-dependent and productivity-focused incremental agricultural innovations (Ruivenkamp et al. 2008) and the first generation of GM crops was one such innovation: crops with built-in herbicide or insect resistance could improve the performance and efficiency of the technology-supported and external input-dependent industrial agriculture. During that same period, increasing disconnection between farmers and farming resources led to progressive transformation of agriculture into 'agribusiness' as, since the 1980s, the necessary means to farm have increasingly been turned into private property by large and powerful actors with the determining asset of financial capital (Kloppenburg 2004; Lemmens 2014). Moreover, at this point, the societal function of agriculture was increasingly considered to be the 'provider of inputs' (for industry) - such as fibres, oils, sugars and starches - rather than the 'producer of crops' - such as potatoes, canola, cotton, corn or beans (Pechlaner 2010, 2012). In this realm, GM crop applications had strong similarities with the dominant neoliberal and industrialised regime - e.g. in terms of scale economy, rationalisation, specialisation and globalisation (Commission of the European Communities COM (85) 750; Potter and Tilzey 2005).

That a technology fits the values of a particular society is not really surprising, as technology development is made possible, or limited by, various lock-in mechanisms within a sociotechnical system such as agriculture. Factors such as existing infrastructure, acquired competencies, established power relationships, institutional commitments or shared beliefs and discourses all determine which new technologies will actually be developed and accepted – or otherwise - within

a society (Geels 2011; Hinrichs 2014). Hence, technologies are shaped by what is believed to be virtuous in a specific society at a specific time. An interesting research question to pose then, is why innovative technologies that apparently 'structurally fit' well with the incumbent agricultural strategies and practices, can still have a hard time breaking through?

Arguing for the incremental nature of first generation GM crops (with improved agronomic traits) may, at first sight, give a biased view and hence be contested as, for instance, the patent regulation with respect to these crops is interpretable as being far more 'radical' (as we will discuss later). This discord explicitly shows the need to take a systemic perspective – instead of an actor-specific view - where technological innovation is related to the structure, culture and practices in place within the sociotechnical EU agricultural system. Such an analysis is important in understanding the ongoing opposition to GM crops in the EU, as well as in extending the current views on technology development, which state that only radical innovations (which exhibit a strong mismatch with prevailing regime practices) require protection such as shielding, nurturing and empowering to break through (Boon et al. 2014; Smith and Raven 2012) (see the glossary on a niche-type of environment).

Until now, these acknowledged forms of 'niche protection' when implementing a new technology have not been stipulated for incremental or regime-aligned innovation of the kind of first generation GM crops. This is probably because such incremental innovations are typically considered to 'simply' align with established power networks, user preferences and infrastructure. Incremental innovations can also more easily and rapidly perform in mainstream markets; they appear in line with the dominant expectations in a sociotechnical system and they can actually benefit from path dependencies - path dependence assumes that technology development and actors' behaviour occur relatively deterministically and rather passively along the lines of existing institutions and routine practices (Garud et al. 2010; Thrane et al. 2010; see also the glossary).

However, the actual implementation level and the high normative contestation about GM crops within EU agriculture today (see also Chapter 1) evokes the thought that only structural fit with incumbent agricultural practices does not directly legitimate or guarantee an incremental innovation to be successfully implemented. Rather, actively establishing an empowering 'niche'-type environment might also be relevant for such innovations as it is apparently not straightforward for any incremental, 'easy' innovation to gratuitously achieve legitimacy.

Therefore, the research questions in this chapter are the following:

(1) Why can apparently incremental innovations have a hard time breaking through? And, in particular, why is the use of first generation GM crops within EU agriculture so highly contested?

(2) Can the niche protection functions that are typically stipulated for embedding radical innovations also be relevant for successfully implementing incremental innovations?

In order to study this context-specificity of (opposition to) developments and appropriation of incremental technologies, we will use the multi-level perspective (MLP) as an analytical framework, with first generation GM crop applications as a case study. The MLP is a well-elaborated heuristic (guiding the analyst's attention to relevant questions and patterns) which helps us to understand the systemic embedding of technological innovation within sociotechnical systems such as EU agriculture. The MLP framework foregrounds structure-agency relationships, and hence enables us to look at the wider societal context and broader sociotechnical networks in which technology implementation takes place (Geels 2011).

5.2 Methodology

5.2.1 The case study: introducing first generation GM crops within EU agriculture

To answer the posed research questions, we will analyse the early developments of first generation GM crops within the sociotechnical EU agricultural system. We are particularly interested in the early stages of this innovation trajectory, because creation of positive meanings at that stage is an important precondition for further investment, support and hence subsequent dissemination of the innovation (Geels and Verhees 2011). The timeframe for the case-study analysis was set between 1983 and 1999; starting at the moment when the first transgenic plant was developed in 1982/83 (an antibiotic-resistant tobacco plant) and ending in 1999 with the de facto moratorium on new GM crop approvals, which signalled a precautionary attitude within the EU political environment that has, so far, proved irreversible (Hristova 2013; Inghelbrecht et al. 2014a; Lieberman and Grey 2006; Swinnen and Vandemoortele 2010).

This timeframe demarcates the first research and development (R&D) period of the innovation trajectory for first generation GM crops in the EU. Based on the work of Joly and Lemarié (1998), it can be seen as a succession of (a) an initial exploration, where research spin-offs and start-ups were launched; (b) consolidation, where transnational companies progressively bought up small and medium biotech enterprises; and (c) an adding value phase, where biotech companies sought

collaborations with both upstream and downstream actors in the chain as a way to expand their research portfolio and to reach agreements with food companies (Joly and Lemarié 1998). In sum, the set timeframe covers both what could be considered as an initial 'flourishing period' of biotech crops as well as the rise of a strong anti-GM movement in the mid to late 1990s in the EU.

5.2.2 Multi-level perspective on transitions as an analytical framework

To describe and analyse the co-evolution between technological and societal developments during the set timeframe, we deployed the multi-level perspective on transitions. The MLP is a middle-range theory that analyses the dynamic patterns that shape sociotechnical transitions in systems such as EU agriculture (Geels 2002, 2004, 2011). Thereby, 'sociotechnical' refers to an emphasis on the co-evolution of social and technological elements and the relationships between them; 'transition' indicates the fundamental change in these relationships (leading to systemic innovation).

Due to this central notion for co-evolution, the MLP can explain both innovation breakthrough and innovation failure (Schot and Geels 2008). It can be used to explain how emerging innovations struggle against existing systems in a multi-dimensional way, as well as to analyse the (re)configuration of prevailing sociotechnical settings (Genus and Coles 2008; Pesch 2015).

The MLP: niches, regime and landscape

In its very essence, the MLP helps to explain how technology implementation and systemic change - within the EU agricultural system in this particular case - happens by mutually reinforcing dynamics at three levels: the ruling sociotechnical regime, the innovative niches and the uncontrollable landscape developments. In highly simplified terms, the MLP conceptualises radical innovation breakthrough as a result of external landscape changes that exert pressure upon the incumbent sociotechnical regime and so open up 'windows of opportunity' that might be exploited by niche innovations (Hargreaves et al. 2013). Although the MLP focuses on explaining the breakthrough of radical innovations, it also offers a more general means of structuring the dominant paradigms within EU agriculture (along the logic of a sociotechnical regime) (Smith and Raven 2012). This sociotechnical regime is of primary interest in the MLP (Genus and Coles 2008), and the niche and landscape levels are defined specifically in relation to that regime, "as practices or technologies that deviate substantially from the existing regime, and as the external environment that influences interactions between niche(s) and regime" (Geels 2011 pg. 26).

The following definitions are given to each of these concepts (Geels 2002, 2004, 2005a, 2011; Geels and Schot 2007; Holtz et al. 2008; Nevens et al. 2016):

(a) the sociotechnical regime encompasses the dominant culture, structure and practices that establish an incumbent system's stable functioning; including the aspects of lock-in, inertia and path dependency. As the locus of established practices and associated institutions, the sociotechnical regime represents and stabilises 'the system'. Examples of regime rules are shared beliefs, lifestyles, regulations, institutional arrangements and (infra)structure in relation to science, technology, policy, the market, etc. In regular circumstances, a sociotechnical regime only changes incrementally to improve its own performance along the dominant paradigms (see also the glossary on paradigm).

(b) sociotechnical niches, as loci for radical innovation, are considered as "protected spaces in which the maturation of new technologies and the alignment with a suitable institutional context can take place" (Fuenfschilling and Truffer 2014 pg. 2). These incubator rooms are deemed necessary because radical innovations face a structural mismatch with existing norms, infrastructure, regulations or user preferences, and therefore require protection.

(c) the landscape, as the exogenous environment, is characterised by three types of dynamics that are either stabilising or destabilising: long-term changes (such as demography, climate change), factors that do not or merely gradually change (such as physical assets), and sudden external shocks (such as wars, catastrophes, and sudden and steep price changes).

The MLP describes the developments within and between niches and regimes (i.e. the niche/regime interface) therefore as a pressure-and support-mechanism that explains the competitiveness or symbiosis of niche and regime, and thereby also focuses on regime stabilisation and reproduction against an overall background of broader social, economic or political changes in the landscape level (Geels and Schot 2008; Pesch 2015).

Operationalising the MLP

The MLP explains innovation breakthrough and system change as "processes in multiple dimensions and at different levels which link up, and reinforce, each other ('circular causality')" (Geels 2011 pg. 29). In practical terms, this circular causality hinders a clear operationalisation and delineation of the three MLP levels. This is, in fact, one of the main criticisms of the MLP (see e.g. Berkhout et al. 2004; Genus and Coles 2008; Markard and Truffer 2008; Tyfield 2014). Yet, as technological and social processes are so closely interwoven and coincidental it will always be

artificial to categorise them along the different levels for any analytical purpose; while this differentiation is necessary to enable reflection on this co-evolution as a way of learning for future technology development. Conceptual frameworks such as the MLP are therefore not 'truth machines' as Geels (2011) formulates it, but rather heuristic devices that guide the analysts' attention to patterns and developments in case study research (Mathijs et al. 2012). Attaining a genuinely systemic perspective is thereby more important than attaining an exhaustively elaborated and 'systematic' underpinning of an MLP analysis (e.g. Geels 2011; Nevens et al., 2016). Also, MLP analysis essentially holds a narrative explanation, which will be partial and situated (Geels and Schot 2010; Scoones et al. 2007; Smith et al. 2010). However, such analyses of real life settings have much to offer for understanding innovation trajectories, as has been already proven by multiple case studies (e.g. Geels 2002, 2005b; Smith 2006).

With a main interest in the macro-patterns of the innovation journey for first generation GM crops within EU agriculture, the case study analysis focused on constructing the analytical narrative of the niche/regime interface rather than on the micro-sociological dynamics between the three MLP levels. This is so because, for some decades, agriculture has been dominated by a modernisation regime that has also profoundly (re)shaped the socio-material landscape (Roep et al. 2003). Moreover, Geels (2011) explains that the three analytical levels of 'niche', 'regime' and 'landscape' refer to different degrees of institutionalisation, but they are not 'hierarchical'. The essence of our analysis was therefore the inclusion of diverse influences as relevant elements in an overall 'rich' picture (Genus and Coles 2008; Checkland and Poulter 2010; Nevens et al. 2016), but no specific emphasis was added to differentiate between 'niche', 'regime' and 'landscape' (Genus and Nor 2007; Nevens et al. 2016; Smith 2007).

As in any MLP exercise, this chapter makes a fair attempt to operationalise the concepts of a sociotechnical regime and a niche configuration, but there are no strict guidelines on how to do so (Genus and Coles 2008; Smith et al. 2010). Basically, we have characterised the dominant field logic - as being the dominant "guiding principles that offer specific rationalities, set the rules of the game, allocate power and status and steer attention towards specific problems and solutions" (Fuenfschilling and Truffer 2014 pg. 4) - within EU agriculture, between 1983-1999, as 'agriculture being the provider of industrial inputs' in terms of being industrialised, productivist, technologised, mono-functional (food production), with a specialised technology-based R&D infrastructure as the locus for innovation; and attempting to reconcile neoliberal imperatives with a continued commitment to state assistance in various forms (embedded neoliberalism)(Fuenfschilling and Truffer 2014; Geels 2011; Pechlaner 2010; Potter and Tilzey 2005; Roep et al. 2003). Evidently, this dominant field logic within the sociotechnical regime has

been challenged during the set timeframe. Since the 1980s, the rise of agri-environmentalism and NGOs, for instance, has inspired an increasing tendency to meet sustainability criteria (Commission of the European Communities COM (85) 333, COM (91) 100; Ellis and Biggs 2001). Since the early 1990s, also institutional commitments to issues such as organic agriculture or fair trade gained ground within EU agriculture; although always being kept on a lower degree of institutionalisation and dominance in comparison to the dominant field logic (Amand-Eeckhout 2012; Michelsen 2009; Stolze and Lampkin 2009). This means that our analysis and operationalisation of the sociotechnical EU agriculture regime, between 1983-1999, outlined the clear dominance of interrelated rules and standard practices for an industrialised, productivity-focused and embedded neoliberal EU farming structure, while not considering this as homogenous (Geels 2011).

In addition, to construct the analytical narrative of the niche/regime interface, our analysis involved a particular focus on four subregimes of the sociotechnical regime: the socio-cultural, the science, market and policy regimes. In particular, the analysis focused on framing struggles in the sociocultural regime, risk conflicts in the science regime, economic considerations in the market regime, and political struggles and opportunity structures in the policy regime (see Sections 5.3.1 to 5.3.4 in this regard). Secondary data sources for this analysis were collected via desk research. These included mainly scientific papers collected via Web of Science and Google Scholar, ranging from historical review papers on agricultural biotechnology (e.g. Devos et al. 2008), interpretative papers (e.g. on the moratorium; Lieberman and Gray 2006), to academic analyses of media communication about GM crops (e.g. Maeseele 2011). Also scientific papers explaining the high level of contestation about this particular innovation were included (e.g. Cook et al. 2004; Smits 2006), as well as legislative texts, reports, and academic papers with both a focus on (changes in) the EU biotechnology legislation (e.g. Directive 90/220/EEC to Directive 2001/18/EC; Gottweis 2008; Hristova 2013) as general policy recommendations on EU agriculture for the set timeframe (e.g. Common Agricultural Policy evolutions; European Commission 2015c).
This implies that we have:

(a) defined the paradigms that were dominant within the four subregimes at the start of the biotech era, in terms of what were the 'taken-for-granted' practices, beliefs and assumptions with a high level of institutionalisation in terms of formal or informal rules (Roep et al. 2003);

(b) analysed whether, and which, paradigm shifts occurred in terms of changed legitimacy (cultural or political) or (perceived) regime performance during the set timeframe (Geels and Verhees 2011; Turnheim and Geels 2012, 2013);

(c) determined how these identified paradigms or shifts related to the GM crop configuration in terms of structural resistance or structural support; and whether these shifts have contributed to institutional change in EU politics on GM crop applications, whether or not in favour of their adoption (e.g. in terms of resources, mind sets or identities).

Concurrent with the general idea of primarily establishing a systemic narrative, the analysis was a balancing act in combining frugality and sufficiency: embracing simplicity as far as possible and as much complexity as necessary to achieve 'completeness' (Binder et al. 2010; Leveson 2011). The essence of the effort was perceived therefore in the actual consideration and inclusion of the diverse influences, topics, facts, etc. as relevant elements of an overall 'rich' narrative of the niche/regime interface (Checkland and Poulter 2010). The main references used to construct the narrative are included in the results in Sections 5.3.1 to 5.3.4.

An extended view on sociotechnical niches

A specific point of attention when using the MLP for this case study analysis was the conceptualisation and operationalisation of sociotechnical niches. Some recent empirics and discussions highlight an expanded view on sociotechnical niches:

(a) Niches do not have to be radical in their entire sociotechnical configuration to eventually and profoundly change the existing regime (Geels and Schot 2007). They do not need to be interpreted (only) as 'revolutions'. They might well be a mixture of avant-garde technological developments and existing techniques, usages and preferences (Mathijs et al. 2012).

(b) It is very difficult to define whether a niche has a symbiotic or a competitive relationship with the incumbent regime, and there is no strict one-on-one relationship that prescribes on how a niche influences the regime and vice versa (Geels and Schot 2007; Mathijs et al. 2012; Whitmarsh 2012). Niches are considered competitive when they are seen as attempts to overthrow or replace the existing regime (Geels 2002, 2004). If they incline to potential adoption by the existing regime as a competence enhancing add-on to solve problems and improve performance, they are rather considered as symbiotic.

(c) This means that niches do not necessarily "always compete with and substitute for the prevailing regime, as was assumed in earlier strategic niche management work [...] the dynamic is less about substitution and more about how niches may branch, pile up, and contribute to changes in the behaviour, practices and routines of existing regime actors.

> This more differentiated view on niche–regime interaction is fruitful terrain for further research. It also shows that niches can play different roles" (Schot and Geels 2008 pg. 547).

As such, sociotechnical niches can influence the sociotechnical regime in a 'double-edged' way and do not only have to be seen as little revolutions. This allows to introduce a more generalised view on sociotechnical niches, going beyond a typical focus of radicalism when deploying the MLP. Rather, these recent developments more explicitly take into account that niche/regime boundaries often shade into each other (Genus and Coles 2008) and that technological niches can have both *confirmative and disruptive conduct* in relation to the incumbent regime structure, culture and practices. Thereby, 'confirmative' and 'disruptive' conduct indicate the matches and mismatches between expectations, rationales, institutions and practices of the incumbent regime and the specific niche configuration, respectively.

In that light, the concepts of confirmative and disruptive conduct in the operationalisation of a sociotechnical niche complement the currently dichotomous categorisation of incremental or radical innovations; as a more nuanced view describes technological innovations with more, or less, confirmative and disruptive conduct. Incremental innovations, then, are configurations with more confirmative than disruptive conduct, while the disruptions can also be somewhat drastic (e.g. the patentability of plants for first generation GM crops). Radical innovations have predominantly disruptive conduct. It also shows that the niche/regime interface, as outlined in MLP work on radical innovation, can be used to understand the systemic implementation of what appear, at first sight, to be incremental innovations, such as the first generation GM crops. The implementation of these innovations may depend as much on co-evolution with societal developments as do radical ones (while acknowledging that incremental innovation can also benefit from the mere stability of the sociotechnical regime). Furthermore, this extended conceptualisation of a sociotechnical niche also allows to approach the sociotechnical regime in terms of being enabling and disabling (Geels and Schot 2008), and to analyse innovation trajectories at intermediate timeframes in an ongoing transition. This can be considered as an important enrichment of MLP analysis, because an exact categorisation of whether an innovation is incremental or radical depends on the emerging co-evolution between technological and social processes (organic farming is a good example; Mathijs et al. 2012; Smith et al. 2010). In a strict sense, whether an innovation is incremental or radical can only be assessed *post hoc* (Tyfield 2014; Whitmarsh 2012). Therefore, the surplus value of approaching sociotechnical niches as a configuration of both confirmative and disruptive conduct is a proactive way to introduce a systems perspective into the design of new technologies and to specifically account for path dependence. We will elaborate on this in the discussion in Section 5.4.2.

5.3 Results

In this section, we describe our findings on how the dominant culture and practices within the sociotechnical EU agricultural regime shifted between 1983 and 1999 (Figure 5.1), and we relate this to evolutions in the GM crop niche. The quest for this specific niche/regime interface – alongside socio-cultural aspects, science, markets and policy - will allow us to unveil important patterns in the early stages of the innovation trajectory for first generation GM crops within EU agriculture as to explain why apparently incremental innovations can still have a hard time breaking through.

5.3.1 From prospect frames to precautionary and anti-GM frames in the socio-cultural regime

The general awareness about how technological innovation is implemented in society encountered a shift in the 1990s, from a linear model of innovation with only a small number of feedback loops, towards a systems perspective where the implementation of technological innovations is regarded as a socially embedded process (Arnold 2004; Geels 2004). This acknowledging of a societal robustness needed for successful technology implementation (Arnold 2004; Hermans et al. 2013), partly coincided with the first period for agricultural biotechnology R&D.

Since societal robustness implies the achievement of 'cultural legitimacy', both proponents and opponents of GM crops have strongly engaged in framing struggles to create or dismiss the cultural legitimacy for GM crop applications within EU agriculture and wider EU food/feed production. Actors such as industry associations, social benefit organisations, policy makers and special interest groups have all publicly debated the specific interpretation, meaning and general ways of approaching GM crops and their applications within the EU (such as in the media, or newspapers) (Geels and Verhees 2011; Inghelbrecht et al. 2014a, 2015).

Although the precautionary and anti-GM frames only gained considerable ground in EU society since the mid-late 1990s (Labrecque et al. 2007), they had been introduced earlier:

- with the first deliberate experimental release of GM crops in France, ecological and environmental precautionary and anti-GM frames entered the EU framing struggle in 1986 (Devos et al. 2008; James and Krattiger 1996);

- in 1995, the European Patent Office stopped granting patents for plants, and the discussions on what is patentable and what is not, complemented by the production of transgenic animals (both reflecting, to some extent, the 'power of science') added ethical and human integrity frames to the debate (Geelhoed 2014; Krimsky 2005; Scott 2000; Van Haperen et al. 2012);
- in 1996, GM crops entered the EU public sphere in a different physical form: the first US transgenic soy and maize was imported into the EU. This shipment was publicly blockaded by NGOs at the port of Antwerp (Belgium) (Devos et al. 2008) and it became a real-world event that enabled an increase in both the 'empirical fit' of the precautionary and anti-GM frames in the EU debate, as well as in their perceived importance ('centrality' of these frames) (Geels and Verhees 2011; see also the glossary on framing struggles).

In 1997, the Novel Food Regulation (EC No 258/97) was enacted, which also regulated the placing of GM food products on the EU market and which, for the first time, made labelling of GM ingredients a legal requirement (although several exemptions were made; e.g. Article 3(4)). These labelling obligations introduced the precautionary and anti-GM frames within the everyday experience of citizens (referred to as 'experiential commensurability' of these frames; Geels and Verhees 2011; see the glossary on framing struggles). EU consumers started to boycott the sale of GM-labelled agri-food products (Devos et al. 2008) and, in 1998, the first EU supermarket announced that it had excluded GM ingredients from its own-branded food products in response, followed by a second wave of excluding GM ingredients in animal derived products (Kalaitzandonakes and Bijman 2003).

With the mad cow disease (Bovine spongiform encephalopathy) and the dioxin food scandals in the mid to late 1990s, the empirical fit of the precautionary and anti-GM frames could increase again because of these real-world events that put the industrial system in negative day light (Young et al. 2008). As a consequence, certain scientists, politicians, biotech companies - amongst others - were faced with discredit; while social movements and pressure groups gained credibility as a result (Cook et al. 2004; Herrick 2005).

The media also played a role in the framing struggle on GM crop applications across wider EU society (Maeseele 2013). In fact, "after the import of Monsanto's Roundup Ready Soya in Europe and the birth of Dolly, cracks start appearing in the hegemonic discourses of elite media on biotechnology […] In general, there is a shift away from 'prospect frames' to 'concern frames', in which especially agbiotech – which sees a steady rise in coverage after 1997 – is represented by 'concern frames'" (Maeseele 2011 pg. 87).

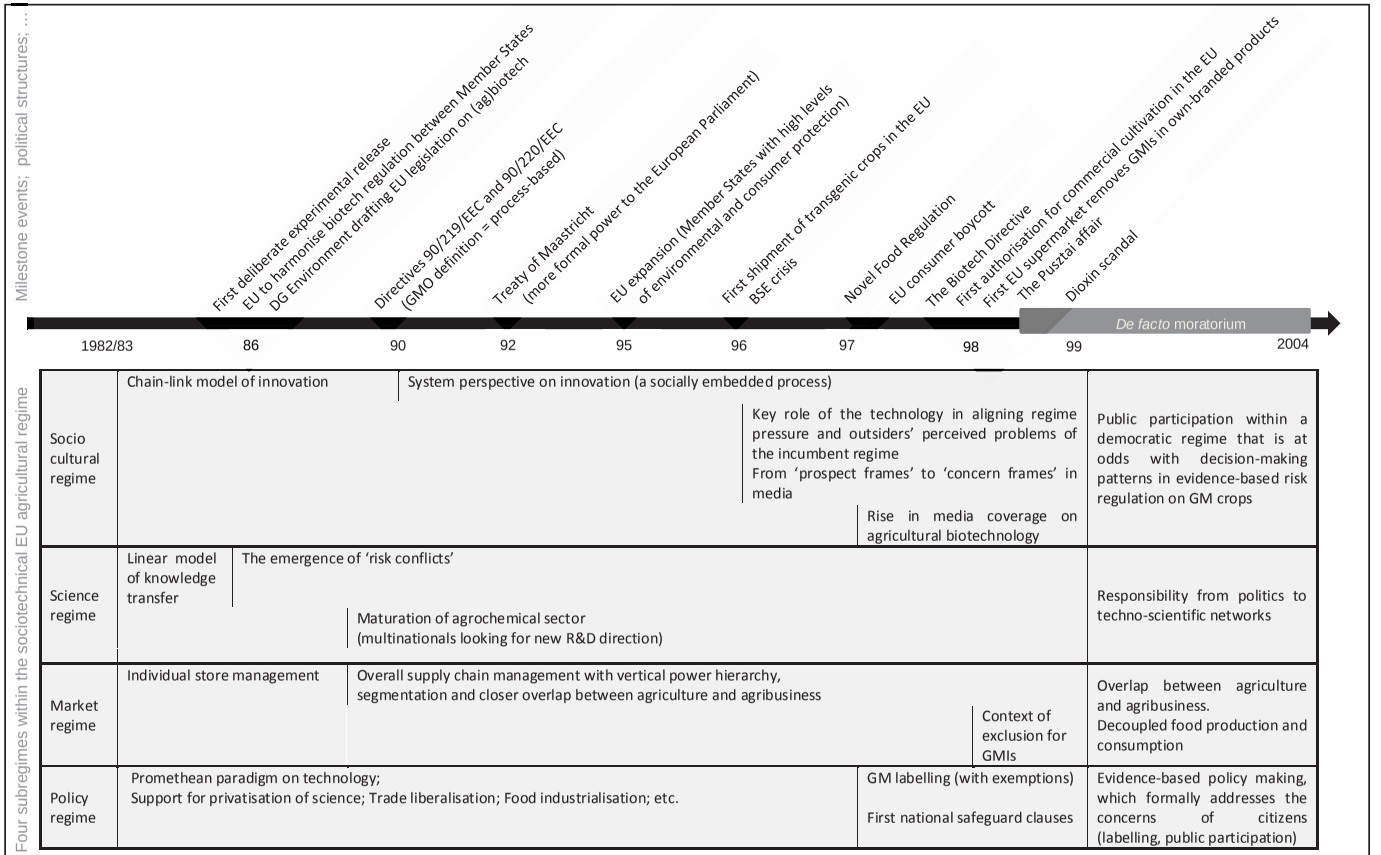


Figure 5.1. Overview of paradigm (shifts) within the sociotechnical EU agricultural regime from 1983-1999. This timeline illustrates our characterisation of the sociotechnical EU agricultural regime specifically in relation to important events and the four subregimes that are discussed in Sections 5.3.1 to 5.3.4.

The UK 'Pusztai affair' in 1998 (the first animal feeding studies showing hazardous health effects of GM food, i.e. GM potatoes) also increased the empirical fit and centrality of the precautionary and anti-GM frames in the EU debate. Protein scientist Pusztai concluded that the negative effects observed were actually the result of the genetic transformation procedure. This case received a great deal of media attention, although later on it was concluded that the data did not support the conclusions (Maeseele 2013).

It is clear that the precautionary and anti-GM frames have gained considerable ground in the EU since the mid-1990s, due to the assets of empirical fit (confirming real-world events), experiential commensurability (everyday experience) and centrality (perceived importance) (Geels and Verhees 2011; Labrecque et al. 2007). As such, the impact of these frames has resulted in an overall absence of cultural legitimacy and societal robustness for GM crop applications in the EU since then. This was important for later phases of the innovation journey and it has influenced the EU politico-institutional environment on GM crops profoundly (De Krom et al. 2014; Devos et al. 2006, 2013; Goorden 2004; Gottweis 2008; Inghelbrecht et al. 2015; Kastenhöfer 2011; Maeseele 2013; Roff 2009). The power of social contestation, in fact, became more profound in relation to GM crop applications than for any other environmental legislation where the environmental risks had not yet been scientifically proven (Rosendal 2005).

5.3.2 From sovereignty to reflexive modernity in the science regime

The first R&D period for agricultural biotechnology coincided with the ongoing privatisation of science, making scientific research incline towards a private rather than a public good; also with a shift from basic to applied research: "inspired by the broader politico-economic context of neoliberalisation, a general shift has taken place from public to private patronage of scientific research since the late 1970s and early 1980s, in conjunction with legislation relating to university patenting" (Maeseele 2013 pg. 3). Agricultural biotechnology was consistent with this new practice of private funding and appropriation of scientific research (Vanloqueren and Baret 2009).

Agricultural biotechnology was also consistent with the reform of capital accumulation in EU agriculture, which positioned novelty creation mainly within capital-intensive and specialised R&D centres (Roep et al. 2003). In addition to this, the agrochemical sector had matured during the 1980s, which made the involved multinational corporations search for new and lucrative R&D directions; agricultural biotechnology was seen as one of the important options to safeguard future business opportunities (Wield et al. 2010).

The science regime in place at the time when agricultural biotechnology was launched thus structurally supported the development and commercialisation of first generation GM crops (Vanloqueren and Baret 2009). However, this science regime still assumed a linear and 'push' model of knowledge transfer based on a predict-and-control paradigm. Scientific knowledge and its deployment were still considered to be powerful enough to organise and structure society (Rijke et al. 2012). Yet, this particular structuring role for science became partially outmoded in the era during which the first R&D period for agricultural biotechnology took place, as, from the mid-1980s, it was no longer widely assumed that scientific and technological advances reliably and solely lead to societal progress (Herrick 2005). Instead, scientific sovereignty was questioned, as scientific research was also supposed to generate new uncertainties, failures and risks. This is what Beck (1992), in his reflexive modernity discourse, defines as the emergence of 'risk conflicts', in which explicit attention is given to the potential consequences of modernisation (Bos 2008; Maeseele 2009). The role of science within society was thus evolving from a rather authoritarian style towards reflexive modernity (Meyer 2006), a phenomenon that essentially made values, norms and institutions nearly equally important to purely rational scientific facts (Bos and Grin 2008; Meyer 2006).

Therefore, the first R&D period for agricultural biotechnology did not take place in a (presumed) vacuum of scientific sovereignty, but within a societal context where science and innovation increasingly required justification – including GM crop applications.

5.3.3 Shifting power in a segmented market regime

During the first R&D period for agricultural biotechnology, a new paradigm of 'vertical power hierarchy' became institutionalised within the agri-food chain. In this paradigm, power is allocated to the downstream actors in the supply chain (Busch 2007, 2011). This shift dated from the late 1980s, when a generation of retailers shifted their individual store management to an overall supply chain management. They started to dictate to upstream suppliers a variety of quantity and quality characteristics for food products, the delivery timings, shelves stocking, etc. (Busch 2007). As the gap between agricultural production and food industrialisation was thus closed further, this new paradigm and the rationale behind it provided structural support for first generation GM crop applications.

'Segmentation' in the agri-food chain was also dominant during the time period of our analysis: operationalising the food production processes into multiple interdependent and specialised (hence more efficient) sub-organisations (Wilkinson 2002). Such organisation of

interdependency and industrialisation within the food supply chain can also be considered as providing a structural support for GM crop applications. That is because these crops can, depending on the GM trait, replace elements within the agricultural production process with industrial ones (called as a potential for 'appropriationism'; Pechlaner 2010). A herbicide resistant GM crop for example reduces the need for tillage practices, but increases dependence on the specific herbicide involved.

These central paradigms within the market regime have offered opportunities, and even some structural support, for the first generation of GM crops in terms of appropriationism, segmentation, and the already institutionalised overlap between agriculture and the food industries. Combined with the narrowing gap between agricultural production and agribusiness, and the increased interest by (agrochemical) multinationals upstream in the supply chain, one might say that the overall market regime in place was generally supportive for practices with first generation GM crops. However, after 1997/98, that favourable situation changed when the Novel Food Regulation introduced mandatory GM-labelling (with exemptions) and when the first EU food manufacturers and supermarkets excluded GM ingredients from their private label range (Inghelbrecht et al. 2015; Kalaitzandonakes and Bijman 2003). This has resulted in an extensive (and ongoing) exclusion of GM ingredients from the EU market. Thus, in spite of a market regime and a EU politico-institutional environment remaining constant to the generic institutions and practices of highly industrialised food production and processing, the specific attitude towards a potentially reinforcing technological innovation changed.

5.3.4 From support to precaution in the policy regime

When agricultural biotechnology was launched, the policy regime in place was supportive for several paradigms that underpinned the sociotechnical configuration for first generation GM crops in EU agriculture. For instance, the privatisation of science, appropriationism, trade liberalisation, and an overlap between agriculture and (food) industrialisation were politically institutionalised (Commission of the European Communities COM (85) 750, COM (91) 258; European Commission 2005, 2015c). The GM crop configuration was also supported politically from a 'promethean' paradigm that considered technological progress as essential for economic growth and necessary for social and ecological processes as to benefit humanity (Dryzek 2010; Gottweis 2008; Maeseele 2009). Along this line, in 1986, the European Commission officially announced the creation of a harmonised (centralised) EU legislation on (agricultural) biotechnology, so as to establish a unified internal EU market and to enhance competitiveness for this innovation (WIV, 2010). In 1998, the first GM crop for actual commercial cultivation in the EU

was authorised (MON 810, an insect-resistant variety of maize), and a formal legislation was put into place which allowed the patentability of GM plants (Directive 98/44/EC) "with the aim of encouraging a strong biotechnology industry in Europe […] The Biotech Directive harmonises patent law between the Member States with respect to biotechnology and ensures that the products of modern biotechnology are patentable throughout the Community" (Gold and Gallochat 2001 pg. 331). GM crops have therefore introduced a new form of capital accumulation within industrial EU agriculture, with practices such as seed saving restrictions, grower contracts and patent infringements. Pechlaner (2010) refers to this new practice as 'expropriationism', which also resulted in a more disempowered role for farmers in crop innovation processes (Kloppenburg 2005).

However, from the early 1990s onwards, the EU approach towards regulating agricultural biotechnology applications (Directives 90/219/EEC and 90/220/EEC) was process-based rather than product-based. In European terms, 'a GMO' was thus officially defined on the basis of its applied recombinant-DNA techniques during development, rather than on the characteristics of the end product (Nap et al. 2003). This can be explained by the fact that "DG Environment [who] was the only Directorate General to advocate a horizontal, process-based regulatory approach to biotechnology […] was ultimately given responsibility for drafting proposal 90/220 and was jointly responsible, with DG Enterprise, for drafting 90/219" (Burns 2012 pg. 348). This means that from the very beginning, the EU regulatory framework on GM crops had an imperative to both foster this innovation (in terms of economic growth) and to address the precautionary concerns about potential impact on health and the environment (Gottweis 2008).

There was significant pressure to change this process-based regulation for GM crops, both from within the EU and externally from the US. However, this process-based premise persisted, as a result of, amongst other factors, the 1995 expansion of the EU with Austria, Sweden and Finland. These three new Member States showed a high level of interest for environmental and consumer protection, and their entry into the EU regulatory decision-making arena provided additional support to other Member States who were sceptical at that time, such as Germany and Denmark (Burns 2012). Furthermore, the Treaty of Maastricht (1992) gave formal decisive power to the European Parliament within the EU regulatory decision-making process on agricultural biotechnology. This provided an ally for (environmental) NGOs who had previously been more excluded from policy-making (Burns 2012).

But public trust in both political and scientific institutions was substantially reduced in the mid-late 1990s due to a number of exogenous shocks - such as the BSE crisis and the dioxin food

scandal (Labrecque et al. 2007). These events created a strong reluctance amongst the European public to accept foodstuffs that they regarded as 'risky' (Devos et al. 2008, 2013). Partly in response, a clear shift in the political attitude towards GM crop applications occurred in the late 1990s, when several Member States utilised the safeguard clauses in the EU Deliberate Release Directive that allowed to provisionally restrict, or prohibit, the use or sale of EU authorised GM agri-food products on their own territory (Geelhoed 2014; Hristova 2013; Lieberman and Gray 2006). Moreover, "on 13 April 1999 the Council adopted a resolution urging the Commission inter alia 'to be, in the future, even more determined to be guided by the precautionary principle in preparing proposals for legislation and in its other consumer-related activities, and develop, as a priority, clear and effective guidelines for the application of this principle' " (EC 2000 pg. 3).

Eventually, political distrust resulted in the de facto political moratorium on new GM crop approvals from 1998-2004 (Lieberman and Grey 2006). This placed strong structural pressure on the sociotechnical configuration for first generation GM crop applications. Because, to restore credibility in the (farm-to-fork) EU food production system and in the EU government in general, policymakers established rigorous and extensive safety procedures, labelling requirements, and traceability regulation. The 6-year moratorium thereby led to an extensively revised regulatory framework that provided legislative answers to discussions on labelling and traceability; it partially took into account public consultation and it applied a precautionary principle to the scientific risk assessment for any GM crop (Devos et al. 2008). This heightened level of precaution and transparency measures increased structural political pressures on GM crops and their applications, although a promethean line of thinking about technological innovation has generally remained in place within EU agricultural policy and practice (De Krom et al. 2014; Goorden 2004; Gottweis 2008; Hristova 2013; Inghelbrecht et al. 2014b; Kastenhöfer 2011; Maeseele 2011; Maeseele et al. 2013; Potter and Tilzey 2005; Skogstad 2011).

5.3.5 Confirmative and disruptive conduct of first generation GM crops

The analytical narrative, as described in Sections 5.3.1 to 3.5.4, points to multiple 'perfect fits' between the sociotechnical configuration for first generation GM crops, and the dominant culture and practices in multiple subregimes of the then incumbent sociotechnical EU agricultural regime. These perfect fits are the 'confirmative conduct' of the configuration and refer, in our case, for example to science privatisation, an applied research focus, the promethean political discourse that supports technological progress, the vertical power hierarchy within the agri-food chain supporting appropriationism, and the narrow gap between agriculture and (food) industrialisation.

At the same time, the analytical narrative also highlights 'disruptive conduct' of the sociotechnical GM crop configuration. This represents, for example, a different form of human control in agricultural crop production and crop breeding processes (Byé and Fonte 1993). It also highlights an additional, new form of capital accumulation within industrial EU agriculture due to seed saving restrictions and patent infringements ('expropriationism'; Pechlaner 2010); and the disruptive conduct includes the disempowerment of farmers in crop innovation processes by ascribing them a more executive role (Kloppenburg 2004).

5.4 Discussion

Based on the case study findings, we now make a more general reflection on why technologies that apparently structurally fit well with an incumbent sociotechnical regime, can still have a hard time breaking through. In Section 5.4.1, we explain this as a consequence of the key symbolic function for (this) specific technology in challenging the cultural legitimacy of generic regime practices. This line of thought shows how legitimacy for an apparently incremental innovation does not directly (or self-evidently) reside in its structural fit with the existing regime. It is rather a discursive process, and the case shows how structural fit can also have drawbacks in that respect. In Section 5.4.2, we discuss whether the niche protection functions that are typically stipulated for radical innovations could also be relevant for successfully implementing incremental innovations. In particular, we empirically underpin the relevance of forming a 'niche'-type environment for structural fit innovation, and we explain which niche protection functions we consider relevant for incremental innovations. These insights can contribute to a better integration of apparently incremental innovation within agriculture and other societal systems.

5.4.1 Specific technology can challenge the cultural legitimacy of generic regime practices

The GM case study confirms how normative concerns, initially formulated by 'regime outsiders' such as special interest groups, can influence the way existing regimes adopt technological innovation (Elzen et al. 2011). The effectiveness of these activities depends on political opportunity structures and on alignment with market developments (Elzen et al. 2011). In this case study, examples are:

(a) DG Environment drafting EU legislation on agricultural biotechnology, the expansion of the EU in 1995 to render assistance for a process-based legislation, and the Treaty of Maastricht which empowered the European Parliament (political opportunity structures).

(b) the strong unwillingness amongst the European public in the late 1990s to embrace foodstuffs that they regarded as risky (e.g. in response to the BSE crisis), the consumer boycott of GM-labelled products and the exclusion of GM ingredients in retailers' business strategy as a response (alignments with market developments).

The analysis also points out a potential key role of new technology in increasing the visibility/tangibility, proximity and awareness of regime problems (Turnheim and Geels 2013): the confirmative and, hence, system reproducing conduct in the GM crop configuration was deployed by regime outsiders to symbolise, and even magnify, several frames of opposition/precaution with regard to globalised, input-dependent and industrialised EU agriculture – highlighting for example the high symbolic value of soya in compound feed production or the power of multinationals in food production

As a concrete living symbol for such a type of agriculture, the GM crop configuration could serve to bring outsiders' perceived 'regime problems' more into the daily life experience of (as yet) unconcerned/unaware actors such as citizens. For example, when NGOs publicly boycotted the first shipment of transgenic crops in Antwerp, globalised agricultural practices (for compound feed production) became a concrete reality rather than a vague concept that people only heard about. First generation GM crops were therefore able to raise awareness about how the agricultural regime functions and upon what logic and values it is based. In general, the confirmative conduct of a sociotechnical configuration that embeds the use of a new technology can therefore increase the centrality, empirical fit and experiential commensurability of the frames of opposition or precautions that regime outsiders put forward against the incumbent regime; and may so contribute to the transformation of the prevailing paradigm. That a specific technology practice can accessibly and concretely be used to stimulate debate about standard regime practices subscribes the need to actively deal with path dependency in the design and introduction trajectories of new incremental technology (next section).

5.4.2 A 'niche'-type of environment for incremental innovation

The primary aim of developing a niche-type environment is to learn about the desirability, the problems and opportunities for a radical novelty. It also seeks to align the interests and expectations of different actors with different aims and priorities, so as to build new actor-networks. Niches also foster institutional adaptations that are necessary for radical innovations; and they allow us to learn about structural regime barriers in implementing these innovations (Boon et al. 2014; Smith and Raven 2012). Niches therefore constructively relate innovations with

regime path dependencies and that is why the breakthrough of radical innovations is accompanied by three so-called niche protection functions: shielding, nurturing and empowering (Kemp et al. 1998; Schot and Geels 2008).

Shielding, involves outward-oriented processes that avert (some of the) incumbent regime selection pressures on new technologies - such as standard user preferences, norms or industrial production standards. Second, nurturing, involves the articulation (and adjustment) of expectations and visions as a way of providing guidance for future innovation activities and to attract attention and engagement (e.g. by financing) from external actors. Nurturing also includes the establishment of strong social networks for the new innovation, as a precondition for gaining sufficient support, and it involves learning processes about user preferences, infrastructure requirements, business models, etc. Third, establishing niches involves empowerment processes, which emphasise that embedding new technology is a discursive process, where actors, for and against, develop narratives and counter narratives to gain or reduce legitimacy and support for the technology or innovation.

Based on the empiricism of this case study, it seems that a niche-type environment could also have benefits for incremental innovations, such as:

(a) establishing heterogeneous/dispersed innovation networks. Only then can elements of potential conflict and different interpretations of the innovation become clear. These different views and interests must be accommodated, e.g. by processes such as creating platforms for discussion, capturing others' perspectives and broadening the scope of the niche (Boon et al. 2014; Smith and Raven 2012; Raven et al. 2015). This is particularly relevant because the confirmative conduct of new technology can accessibly be used by regime outsiders to revive/reinforce certain discourses that criticise institutionalised practices within EU agriculture (Section 5.4.1).

(b) second-order learning. When developing an innovation network for incremental innovations it is important to (re)question the specific goals, vested interests, and standards of the actors involved (Poppe et al. 2009). Otherwise these blind spots automatically result in confirmative conduct that is, as such, taken for granted (Boon et al. 2014). That is why second-order learning is important in relation to incremental innovations, as then it is not just the actors' perspectives of solutions and strategies that change, but also their perception of the actual problems and challenges at hand (see also the glossary on second-order learning).

(c) going beyond a simple 'fit-and-conform' empowerment for incremental innovation. Fit-and-conform narratives argue that the innovation can become competitive in terms of conventional regime criteria (Smith and Raven 2012). However, these narratives will not resonate with regime opponents - regardless of attempts to establish heterogeneous networks. Future research should therefore investigate in more detail how this discursive process should evolve. Examples here may be that both 'fit-and-conform' and 'stretch-and-transform' narratives have to be present when arguing for the broader sociotechnical implications of the incremental innovation (Raven et al. 2015; Smith and Raven 2012); or, perhaps, the narratives can be oriented towards long-term regime practices rather than trying to align with today's regime culture, structures and practices.

The most important conclusion of this analysis is, therefore, that social legitimacy for an incremental innovation should not be taken for granted. Indeed, the GM crop case has shown that many established regime practices were either taken for granted or they were not seen as a 'personal affair'. For instance, when the regime element of privatisation of scientific research came under societal pressure, agricultural biotech companies could have commissioned universities to prove GM crop safety, for example, rather than keeping it in-house, assuming that others would address these generic regime pressures. Or, when actors argue 'what a bad coincidence' it was that the first generation of GM crops provided enhanced input traits for the benefit of farmers, instead of offering benefits to consumers, then an a priori reflection on the confirmative conduct of this sociotechnical configuration could have identified this as a form of path dependence.

The essence of creating a niche-type environment for incremental innovation is therefore, first, to allow the establishment of a second-order learning environment where heterogeneous networks can develop (this is important because the confirmative conduct of new technology can accessibly be used by regime outsiders in discursive battles). Second, it entails an empowering environment to increase the discursive strength of the incremental innovation, by including actors both from within and outside the network (Boon et al. 2014; Raven et al. 2015; Smith and Raven 2012).

Two of the three processes that facilitate niche protection for radical innovations – 'nurturing' and 'empowering' - seem thus also very important to realise more successful implementation of incremental innovations. The niche protection function of 'shielding', which moderates regime selection pressure for radical innovations, might be less accurate in case of incremental innovation because innovations of the latter kind will most probably perform well in the mainstream (technological) settings; chances are high that there is already a dedicated R&D

community for these types of innovation; and the need for experiments, demonstration or pilot projects seems to be less (Verhees et al. 2015).

So, while the creation of niches for radical innovations is associated with the articulation of expectations, promises and vision that lead to a shared agenda (Raven et al. 2015; Verhees et al. 2015), this case study shows that creating a niche-type environment with the functions of nurturing and empowering might be very relevant to successfully implement apparently incremental innovations. These insights can be instrumental for further innovation trajectories within agriculture or other sectors or societal systems.

5.5 Conclusion

This chapter has analysed why apparently incremental innovations can still have a hard time breaking through (RQ4),

- by emphasising the importance of co-evolution between technological and societal developments;
- by emphasising the importance of a systems perspective, approaching the innovation in terms of both confirmative and disruptive conduct;
- by emphasising the importance of second-order learning and empowerment of an apparently incremental innovation;
- by showing that new technologies can induce discursive battles about institutionalised regime practices.

As a possible way forward, we have emphasised the relevance of creating a 'niche'-type of environment with the functions of 'nurturing' and 'empowering' these innovations. That is because it is important not just to empower apparently incremental innovations by fit-and-conform narratives – as may be the case today- and because it is essential not to simply assume justification for already established regime practices per se.

In particular, the narrative showed how the introduction of GM crop applications could stimulate debate about institutionalised practices within EU agriculture. Parts of the discussion about GM crops can therefore be explained as an attempt to discuss norms and practices that are standardised within EU agriculture, in order to turn these into topics for discussion and reassessment, because new technologies can take moral routines out of their self-evident

invisibility and turn these again into ethical issues (Swierstra and Rip 2007; see also Chapter 6 and the glossary on ethics and morality). This may then explain why GM crop applications are so highly contested within EU society (RQ4); and why it is an interesting case from which to learn.

The analytical narrative also shows several elements that characterise the sociotechnical lock-in under study (RQ1). For example, important regime elements that seem to socially reproduce the lock-in for GM crops within EU agriculture are commodity agriculture, with product standardisation, bulk production and uniformity of agricultural products; a vertical power hierarchy and segmentation in the supply chain; levels of output as a measure of efficiency; the institutionalised overlap between agriculture and the food industry; the role of science in providing answers; or science as an objectifying discipline. We will characterise this lock-in further in Chapter 7.

CHAPTER 6.

WHEN TECHNOLOGY IS MORE THAN INSTRUMENTAL: HOW ETHICAL CONCERNS IN AGRICULTURE CO-EVOLVED WITH THE DEVELOPMENT OF GM CROPS

Technology is more than 'a thing' to use.

CHAPTER 6.
WHEN TECHNOLOGY IS MORE THAN INSTRUMENTAL: HOW ETHICAL CONCERNS IN AGRICULTURE CO-EVOLVED WITH THE DEVELOPMENT OF GM CROPS

"It is not that we use technology. We live technology." (Godfrey Reggio)

This chapter provides a better understanding of the sociotechnical practices in which GM crops are currently embedded and how these practices relate to the prevailing structure within EU agriculture. For this, we will analyse how, within their current use context, GM crops can be understood as actively mediating human interpretation and human practice (RQ5).

In this chapter, we explain that the public interpretation of a GM crop converges with certain (types of) practices in the EU. We explore the moral significance of GM crops within this current (mono)stability of the technology by explaining how particular mediations of GM crops have helped to shape human interpretation and human practice in agriculture today. This will illustrate how ethical concerns about agricultural practices have co-evolved with the material development of GM crops.

Overall, the mediation analysis helps to explain why this particular incremental innovation is so heavily contested within the EU (RQ4). The analysis also presents a new and broader view on GM technology which allows us to make some suggestions about how to extend the ongoing debate beyond the Yes/No framing (RQ2). The analysis also contributes to the identification of several regime elements that socially reproduce the sociotechnical lock-in under study (RQ1).

6.1 Introduction

Technologies 'are what they are' because of the meaning that is conveyed on them by particular ways of using them (Verbeek 2011). This enables technologies to have different identities and this also means that they can have different roles in society with a corresponding moral significance depending upon the particular use of the technology (see the glossary on moral significance of technology). Technologies are not just passive instruments at human disposal. Instead, the mediation theory of Verbeek argues that technologies act as mediators of human-world relations, in a multistable way, so that "the mediating role of technologies comes about in a complex interplay between technologies and their users. Technologies are multistable […] They have no

fixed identity but get defined only in their context of use. Technologies have to be interpreted and appropriated by their users to be more than just objects lying around. Only when human beings use them, artefacts become artefacts for doing something. And this 'for doing something' is determined not entirely by the properties of the artefact itself but also by the ways users deal with them" (Verbeek 2006a pg. 371). A technology's meaning and identity then, is derived from human-technology associations. One no longer speaks of a technology 'in itself' (Whytse 2015).

Taking this perspective on technology, in this chapter we question how, within their current use context, GM crops can mediate human interpretation and human practice. This technology is of particular interest, because after more than 30 years, the debate on GM crops is still profound and highly polarised within EU society.

Today, the public interpretation and meaning for a GM crop tends to be automatically associated with economies of scale, intellectual property rights, technological control, and a strictly executive role for the farmer in crop production (Lemmens 2014; Pechlaner 2012). GM crop applications are thereby automatically linked to "a global agricultural order based on corporate control of agriculture, [and] strong private property rights" (Ruivenkamp et al. 2008 pg. 246). Only one kind of agricultural biotechnology seems to exist; one that is supported by a complex network of actors that includes agribusiness, regulatory agencies and agricultural research institutes, amongst a few others (Ruivenkamp et al. 2008). This generalised view on GM crops is also reinforced by a legislative interpretation of 'a GMO' which applies a process-based definition and identical labelling criteria for all GM crop/trait combinations within the EU (see Chapter 1). This may be why many actors reject GM crops *per se*, without considering them on a case-by-case basis (Blancke et al. 2015; Smits 2006).
However, intellectual property rights, economies of scale, and an executive role for the farmer have all emerged by appropriating the technology within a particular practice and can therefore be considered as a human intentionality. Technological control, on the other hand, is obtained by instilling specific qualities into the seed and can thus be considered as a technological intentionality, conveying a certain intention on its users (e.g. herbicide-resistance or insect-resistance have a strong inclination towards changing the practice of farming). One can therefore observe a very particular, emergent combination of human and technological intentionality in the production, dissemination and use of a GM crop. As we will demonstrate, it is this human-technology association that determines the social role and the moral significance of these crop applications - something that, although important, is currently not given adequate consideration in the design of, or the debate on, GM crop applications in the EU.

Instead, we observe clusters of arguments in relation to technological instrumentalism and technological determinism. Technological instrumentalism considers GM crops merely as a means to achieve a certain human purpose and to fulfil a certain function. Technology is hereby considered as inert and without operative power. All that counts is what we do with the technology. From this perspective, a particular technology can be embedded within any practice because of its presumed neutrality. This is illustrated by claims that a GM crop, for example, fits into any type of farming, ranging from organic to conventional agricultural practices (Popoff et al. 2013). Therefore, technological intentionality gets disregarded in views of technological instrumentalism (VIB 2014). However, this view neglects a crucial aspect of technological reality, as, for example, a herbicide-resistant GM crop materialises external input dependence in crop production and 'demands' to be sprayed with herbicides; while a drought-resistant GM crop materialises ecological modernisation, as it offers a shortcut solution to direct needs in changing the structure of our production system to cope with environmental problems (Bos and Grin 2008). The technological intentionalities and moral significance of these different traits are different, but this difference is denied in views of technological instrumentalism.

Arguments relating to technological determinism are also present in the ongoing debate. Here, the idea is that technology is an actor that operates completely independent of human choice. Technological determinism subordinates the context of use to the technology's own 'power to act'. In these arguments, GM crops are, for example, presented as Frankenstein food which overrules our human autonomy, or in this argumentation practices such as monoculture cultivation and scale economy in crop production are systematically linked to any GM crop as an inherent characteristic (Lemmens 2014; Pechlaner 2010). Also this view neglects a crucial aspect of technological reality, as, human intentionality gets disregarded in views of technological determinism.

Interestingly, both technological instrumentalism and technological determinism share an externalist, or exogenous, view on technology. Both see technology, once designed, as completely detached from human intentions (Swierstra and Rip 2007), either as an all-encompassing negative force that determines societal evolution or as a neutral instrument that can be employed at will. However, from the perspective of technological mediation, where technologies are understood within their activities (Whytse 2015), this disregard for human-technology associations and human and technological intentionalities can explain why the ongoing debate about GM crops has been narrowed down to a social polarisation; to a dichotomous Yes/No framing on whether or not to include GM crop applications within EU agricultural practices.

Specifically, a strong externalist, or socially disembedded, view on this technology amongst both proponents and opponents, makes GM crops a 'take it or leave it' issue for both sides, as "(bio)technology [is seen] as existing outside society, and exerting 'effects' upon it from this external position. Consequently, both proponents and critics hold the same absolutist view about the technology, so that it can only be accepted or rejected *tout court*" (Ruivenkamp et al. 2008, own emphasis in italics). Consequently, the discussion mainly focuses on the acceptability of GM crops and on minimising the negative consequences of introducing this technology, while excluding alternative ways of relating to the technology within new practices (Devos et al. 2014).

Moreover, disregarding human-technology associations and human and technological intentionalities strongly contributes to a fixed identity for all GM crops. This is an identity where the public interpretation of a GM crop is almost automatically associated with a conventional, globalised agriculture, economies of scale, separate R&D, intellectual property rights, and a strictly executive role for the farmer in crop production. These aspects are seen as inherent properties or characteristics of a GM crop, and not as variables for each new GM crop (although, in essence, they are variables within every new sociotechnical practice). Increasingly, these aspects determine what a GM crop 'is'. That is why we can analytically delineate this as one form of stability for the technology ('mono'-stability) - as the public interpretation of a GM crop currently converges with certain (types of) practices.
Also, the discourse analysis in Chapter 3 subscribes to this form of giving meaning to a GM crop, as practices such as globalisation and an economy of scale were strongly present in the first and third discourses, and a strong focus on the mere acceptability of GM crops was present in the second discourse.

For GM crops, this mono-stability is also characterised (and reinforced) by a kind of 'mono-identity' for all GM crops, based on the observation that many actors reject GM crops as a whole, rather than considering them on a case-by-case basis (Ammann 2014; McHughen and Wager 2010). Also, the process-based definition of 'a GMO' and the identical labelling criteria for all GM crop/trait combinations identifies all GM crops together. As a consequence, public interpretation of a GM crop is often not specific to a particular crop/trait combination (Blancke et al. 2015).

Mainly a Yes/No discussion

We can indeed observe a number of political practices that reinforce a social polarisation on GM crops, such as the current GM labelling standard in the EU. Today, the use of a GM label is only required for products that contain, or are derived from, a GM crop (Gruère and Rao 2007).

However, the label is identical for every GM crop/trait combination and for every sociotechnical practice that embeds the production, dissemination and use of a GM crop. This GM label therefore does not permit a discussion beyond a Yes/No framing and reconfirms the dichotomous 'take it or leave it' attitude, because the label simply does not inform individuals about the particular GM crop practice (see also Section 6.5). This removes the opportunity for individuals to relate to this technology in alternative ways and the GM-label only enables limited individual empowerment by offering individuals freedom of choice between two specific options. In line with Foucault's analysis of the relationship between power and freedom, power currently lies with those who determine 'the options' available, such as the gatekeepers in the food industry or politicians who are in charge of GM crop authorisations (Laidlaw 2002).

Also, the process-based EU definition of a GM crop disables a debate on GM crops beyond a Yes/No framing. In European terms, 'a GMO' is defined on the basis of its applied recombinant-DNA techniques (Gruère and Rao 2007). This implies that all GM crops are treated the same under EU legislation, regardless of the particular trait or crop type. From a perspective of human-technological associations in mediation theory, the technological intentionality that differs between different GM crop applications is therefore not taken into account within EU legislation or within the surrounding debate. Moreover, only the safety and risks of the technology is assessed when authorising GM crops in the EU, while the specific user practices that appropriate the technology are disregarded. By denying such human intentionality when developing and authorising GM crops, the motives of the technology developers are taken as a given (Ruivenkamp et al. 2008). The technology is then supposed to speak for itself, hence receiving agency, which results in a 'take it or leave it' attitude once more (Swierstra and Rip 2007) (see also Section 6.2).

The relevance of mediation theory

The above introduction describes the general observation that the EU debate on GM crops is currently a strong Yes/No discussion based on an externalist, absolutist view on this technology. It is stabilised under the current mono-stability (and mono-identity), where the overall public interpretation of a GM crop converges with certain (types of) practices, without consideration of the human-technology association, or of the alternative ways for relating to GM crop applications. This form of debate can be considered as a practical example of Verbeek's (2008, 2011, 2014) criticism on many ongoing debates about technology. From his perspective of mediation theory, many debates about technology focus only on safety issues and only define a set of criteria in which the technology can be permitted (as technologies are rarely prohibited; Verbeek 2011). These debates are characterised by an externalist view on technology with an overall absence of

consideration as to how technology and humans mutually constitute each other. However, "while fulfilling their function, technologies do more [than nothing]: they give shape to what we do and how we experience the world" (pg. 1). Our moral standards therefore develop through close interaction with technology and our actions are not just the result of human intentions, but are co-shaped and transformed by the material world.

Rather than focussing only on the acceptability of GM crops in Yes/No terms, and on minimising the negative consequences of the introduction of this technology within EU agriculture, we should assess the impact of the mediating capacities of this technology in its use context (Verbeek 2008a, 2014). This means a shift in focus towards defining how this technology shapes (and has shaped) human interpretation and human action by looking at "the way in which the technology helps to constitute human subjects, the world they experience, and the way they live their lives" (Verbeek 2011 pg. 94).

To explain contestation about technology, mediation theory tries to look beyond the discrepancy between actors, in terms of scattered norms, ideologies and priorities, and to estimate the moral significance of technology in today's very concrete practices, in our case of GM crops. The central research questions in this chapter are therefore:

(1) How can mediation theory open up a new perspective upon the current debate on GM crops within EU agriculture?

(2) Within their current use context, how do GM crops actively mediate human interpretation and human practice?

In what follows, we will first briefly discuss mediation theory and its view on the social role and moral significance of technology (Section 6.2). Then, we will explore the moral significance of GM crops within their current use context (mono-stability) (Section 6.3). We will do so by estimating how GM crops mediate a farmer - world relationship which actively shapes both human interpretation and human practice in agriculture today. In Section 6.4, we will use this technological mediation analysis to shed new light on the ongoing debate, by explaining how new technologies can take moral routines out of their self-evident invisibility and turn these 'passive' or 'cold' moralities into 'active' or 'hot' ethics (see also the glossary on ethics, morality and technological mediation). Finally, we will refocus on the possible multi-stability of GM crops, paying explicit attention to the script logic and user logic that will be foregrounded and illustrated in Section 6.5.

6.2 Moral significance of technology: introduction to mediation theory

From a perspective of mediation theory, technologies are not just neutral devices that simply 'do as we say'. Mediation theory explains that technologies transform the way humans perceive the world around them and that technologies change the way people act. That is because technologies facilitate people's involvement with reality as mediators of human-world relationships (Verbeek 2006b, 2011). Namely,

- technologies affect how the world exists for us, through mechanisms of amplification and reduction of certain aspects. Looking at a tree, for example, with an infrared camera presents certain aspects of that tree, while, at the same time, it obscures others.
- technologies affect how humans act in the world, through mechanisms for inviting or inhibiting certain actions over others. Email, for example, has deeply shaped the way we communicate, by inviting us to use it for instant connectivity, rather than a regular postal service.

Technologies therefore actively shape what people do; how people experience the world, and technologies help to shape society, including its social relationships and norms (Driessen and Heutinck 2015; Swierstra et al. 2009). That is why, from a perspective of mediation theory, one has to think in human-technology associations. Human intentionalities are not just operative 'through' technologies. Instead, intentionality is located within human-technology associations and thus partly also *in* artefacts (Verbeek 2011). For example, when a thermometer shows a human temperature of 40°C, then it is not the thermometer itself that tells you that you are ill and should stay in bed. It is the combination of technological intentionality ('measuring degrees of temperature') together with a human intentionality ('40°C is serious enough to stay in bed') that defines the technologically mediated decision to stay in bed.

From the perspective of mediation theory, humans 'are' technologically constituted subjects that act in the world (depending upon how the world is present to them); and the objective world 'is' a technologically disclosed presentation of reality that is acted upon by technologically mediated subjects (Goeminne and Paredis 2011). Subjects and objects, or humans and the world, are therefore mutually constituted in a technologically mediated relationship that makes them the way they are. This relationship is represented by placing 'the human' and 'the world' between brackets, as follows: (Human) - Technology - (World). From a somewhat more philosophical viewpoint, this shows that mediation theory adheres to a so-called postphenomenological perspective (Verbeek 2006b, 2010, 2012; Whyte 2015). In postphenomenology, "reality arises

within technologically mediated relations between humans and the world. Subject and object constitute each other in this mutual relation. So, artifacts are not just mediating humans; mediation constitutes both subjects and objects simultaneously: humans and the world they experience are the products of technological mediation, and not just the poles between which the mediation plays itself out" (Waelbers 2009 pg. 244).

Some technologies are more directional than others in disclosing the world or suggesting practical affordances. Particular technologies, such as many GM crops, have a rather explicit directedness as they construct reality or action in a more direct way when interacting with human beings. A herbicide-resistant GM crop, for instance, 'demands' to be sprayed and thus has a certain inclination in terms of the way it is farmed. However, independent of this level of directionality, technological intentionality cannot be considered as inflexibly shaping human behaviour as this would, in line with technological determinism, disregard the flexibility of the use context that actually has to endorse the prescribed program of action for the technology.
Many technologies therefore have intentions for their users and direct the users to use them in a certain way, but technological intentionality is not a self-acting property of artefacts. This makes the intentionality of technological artefacts a different kind to the intentionality of humans: technologies obtain their shape within the relationship that humans have with these artefacts (Verbeek 2012). Technologically mediated effects are thus both directed by technological intentionality and dependent on the specific contexts-of-use and human appropriation of the technology. This means that technologies offer specific windows on the world, as well as specific opportunities for action, while the user context interprets and appropriates the affordances of the technology in line with its own perceptions and programs for action.

A well-known example to illustrate technological mediation is the use of obstetric ultrasound during human pregnancy (Verbeek 2008b). In elaborating this paradigmatic example of mediation theory, Verbeek nicely explains how this technological practice is much more than 'an innocent look' at the unborn child within the mother's womb. He convincingly shows how this 'peek into the womb' has changed not only our interpretation and valuation of unborn life, but also the relationships between the unborn foetus and the expectant parents, including the emergence of new, hitherto non-existent situations for moral decision-making.
For example, obstetric ultrasound shows the foetus more as an individual person, giving it an identity independent from its mother's body. The mother is thereby seen more as the environment where the unborn child develops, rather than being one with the unborn foetus. As a result, women also become more responsible for the wellbeing of the developing foetus. Their eating, drinking and smoking behaviour during pregnancy is monitored, for example. Obstetric

ultrasound can also affect the bonding of expectant parents with the baby. The special one-on-one relationship between mother and child may become more detached, but the bonding between mother, father and the unborn child may be fostered because the father can now 'see' his child. By allowing for specific measurements (such as measuring the degree of nuchal translucency), obstetric ultrasound also presents the foetus as a patient, generating for expectant parents a specific situation of choice: to know, or not to know; to accept, or not to accept, a child with a disability. Obstetric ultrasound may therefore also change the norm on 'having a normal child'. Or parents raising a child with a disability can even be said to have chosen to raise a child with a disability, as if it is more their own choice ('they could have known'). Verbeek nicely recapitulates this overall technological mediation as how *expecting* a child now becomes *choosing* a child - including the choice to have tests done, the choice of what to do if anything appears to be wrong, or the decision to terminate the pregnancy.
However, a decision to have an abortion in this context is not made by the technology nor is it strictly made because of the technology. A decision for abortion occurs as a combination of human and technological intentionality, where the parents choose in combination with the doctor's advice, the latter based on his interpretation of the ultrasound imaging data. Abortion is more of a technologically mediated decision where the ultrasound itself did not make the decision for abortion, but this decision would not have been taken without the scan either. It is precisely this combination of technological and human intentionality that creates a new hybrid actor that decides about abortion. Rather than interacting with the technology, we thus form an association with it, and interact through the technology with the world around us (Verbeek 2006b). So, we do not use technology; we live technology (Godfrey Reggio).

Postphenomenology therefore argues that technologies should be understood within practical engagement, and that human intentionalities are not operative 'through' technologies but located instead within human-technology associations. Technologies-in-use thus have a moral significance, as they have an important influence on perceptions of what is 'right' and 'wrong'. However, this does not mean that technologies are autonomous moral actors (they do not impede morality); rather technologies constitute morality (Verbeek 2011).

Technological mediation is therefore the combined result of the designers who inscribe forms of use and interaction into the technology (leading to a particular technological intentionality), the users who appropriate the technology (along a human intentionality), and the technology itself (as a technology-in-use can evoke 'emergent' forms of use and action). This complex interplay of how technological mediation comes into being as a result of the interaction between designers, users and the technology itself is shown in Figure 6.1. Technologies-in-use thus actively shape

both human interpretation (called hermeneutic mediation) and human praxis (called pragmatic mediation), in both intended and unintended ways, yet, a technology's resulting meaning and identity depends on how the technology is used within a sociotechnical practice (Waelbers 2009).

Technologies thus only have meaning within a specific use context. This implies that technologies display 'multi-stability' with regard to different societal practices, as shown, for instance, in cases of cross-cultural technology transfer. One and the same material technology can therefore have different social roles or moral significances, depending on how its use is stabilised within a particular human use-context. Technologies should therefore be understood *within their activities* and the technology's identity is entirely derivative of that user entanglement (Whytse 2015). This is a major premise of mediation theory: technologies have no fixed identities, but instead are defined within their context of use, where they are 'interpreted' and 'appropriated' by their users (Verbeek 2006 a, b).

However, the ways in which a new technology is designed, interpreted, or appropriated, will be influenced by the existing regime structures (such as prevailing user preferences, norms, routines) (Feenberg 2009; Kaplan 2009). In this example of obstetric ultrasound, a macro-perceptual influence can explain, for example, why the foetus is imagined as having the characteristics of a person. These qualities are not accidental, but in part the result of the standards used for sonograms in order to produce such an image (Whyte 2015). The ways in which this technology has been designed, and the ways of interpreting its forms of use, are therefore partially predetermined by the structures in place within sociotechnical systems. "A different set of standards, or no such standards at all, would produce a different image" (Whyte 2015 pg. 77). Postphenomenologically speaking, the foetus can thus be interpreted based on the specific ways in which it is (re)presented (Verbeek 2008b). More attention is however needed in mediation theory to account for this macro-perceptual influence (see Section 6.3).

6.3 Moral imagination at work: estimating technological mediation of GM crops

Performing a mediation analysis for an agricultural innovation is complex, because there is no clear 'one-on-one' human/technology relation that can be studied, as in the case of obstetric ultrasound for example. There are many more actors involved, from the farmers who actually use the technology, through the supply chain, to the end-user of the agricultural product.

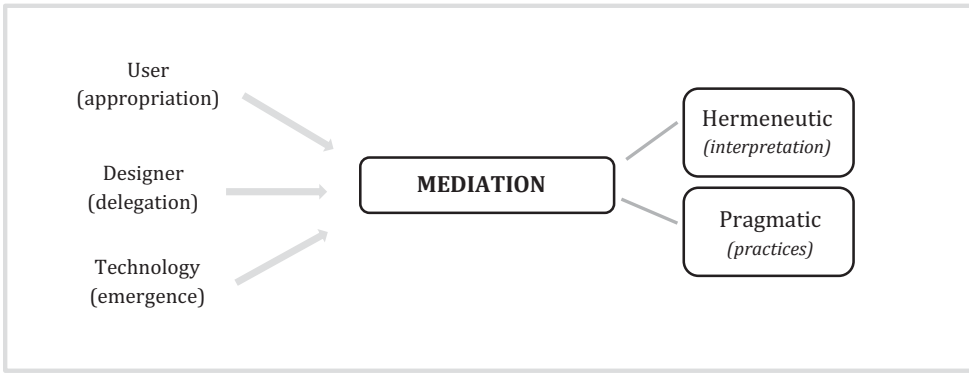


Figure 6.1. Agency and sources of technological mediation. This figure is copied from Verbeek (2011) pg. 99.

However, somehow, we need to consider the application of mediation theory (with a more individual, personal focus) within an agricultural setting, because agricultural technologies also affect the way we 'see' the world (in the first instance, how we see agriculture), and how we operate within it. For this reason we will focus our mediation analysis on the farmer. This allows us to specify the human-world relationship that GM crops mediate to a (Farmer) - Technology – (Agricultural world) relationship. How is the agricultural world presented and how is the farmer present within this world (what moral subject is created)? In addition, we have shifted our focus towards the whole user-practice associated with the technology (i.e. the sociotechnical practices that embed the use of this agricultural technology). This places greater emphasis on the network character in mediation theory, which is derived from actor-network theory (Verbeek 2011) and it better takes into account how technological intentionality and macro-perceptual concerns influence the development of the future user practice(s).

6.3.1 Anticipating mediations of a technology-in-use

Verbeek's (2011) methodology of moral imagination estimates technological mediation effects by imagining the ways in which a technology-in-design can shape user operations and interpretations. Designers thereby try to imagine "how the technology could help to shape specific practices and ways of taking up with reality and how it could shape experiences and ways of interpreting reality" (pg. 100). Our analysis will estimate such mediation effects within a particular context of use, namely within the particular mono-stability of GM crops within EU agriculture (Section 6.1). This shifts the focus of analysis from anticipating possible mediations of a technology-in-design to analysing possible mediations of a technology-in-use within a particular stability. We therefore had to include the technology's embeddedness within institutionalised

practices and institutions, so specific attention was given to the confirmative character of the technology's mediation in relation to dominant practices within EU agriculture. We use the term 'confirmative mediation' to refer to this affirmative aspect of technological mediation. Contrary to 'disruptive mediation', this points to mediations that reproduce the grammar of a particular sociotechnical system.

Of course, when focusing only on how the subject and object are co-shaped within the micro-perceptual sphere in a mediation analysis (Kaplan 2009), it is difficult to see what is innovated, and what is confirmed. However, when taking into account that both the specific amplifications, reductions, invitations and inhibitions within the technology design, as well as the macro-perceptual concerns, co-determine how a technological user-practice develops (in line with the explanations given above), the confirmative and disruptive mediation are revealed within the whole sociotechnical practice associated with the technology (as technologies are defined within their activities; Whyte 2015). The concepts of confirmative and disruptive mediation should therefore not be placed alongside hermeneutic and pragmatic forms of mediation; they are instead a qualification resulting from the inclusion of a systemic relationship within the mediation analysis (see also Section 6.3.5).

6.3.2 Mediation theory extended: confirmative and disruptive mediation

This mediation analysis includes both confirmative and disruptive mediations, defined as technological amplifications, reductions, invitations or inhibitions that respectively confirm or reinforce, or that disrupt or innovate, the current ways of thinking and acting in the world of EU agriculture. These were defined in relation to the dominant paradigms within the current EU agricultural regime, the latter being characterised as mainly industrialised, technologised, mono-functional (food production) and with a specialised R&D infrastructure for agricultural innovation (based on Bos 2008, Geels 2011; Hristova 2013; Potter and Tilzey 2005; Skogstad 2011; Vanloqueren and Baret 2009).

A specific emphasis on including confirmative mediations in this case-study analysis is new, and it responds to a more widely voiced criticism of mediation theory that it maintains a one-sided focus on the disruptive mediations of new technologies (Feenberg 2009; Rao et al. 2015). Namely, mediation theory is often criticised for decontextualizing the use context from the broader societal system and neglecting, for example, the distribution of social power, production standards or user preferences that are already embedded within the system (Feenberg 2009; Rao et al. 2015; Van

Den Eede 2015). Mediation theory is thus criticised for resulting in an *a*political analysis of technological mediation, where no attention is paid to the systemic, macro-perceptual context in explaining why (and how) technologies are designed, interpreted, and appropriated (see e.g. Kaplan 2009; Feenberg 2009). Instead, mediation theory focuses on an existential phenomenology of "how subject and object are co-shaped, rather than how societies and objects are co-shaped" (Kaplan 2009; pg. 236).

In the wording of Van Den Eede (2011), in an analysis of technological mediation "too much attention is given to the odd (e.g., the new), while on the other hand too little is proffered to the obvious—the ubiquitous (pg. 141) (see also Verbeek 2012 in this regard). Yet, structures in place within a sociotechnical system such as agriculture are structur*ing* for human perceptions and actions (Giddens 1984; Sewell 1992) (see also Chapter 2). All actors in that system, including the designers and users of new technology, are partially institutionalised by an established regime logic, which in turn structurally shapes and constrains these human actions and reasoning. This structuring partially occurs outside the subjective perception of agents. Acknowledging these structuring effects within a technological mediation analysis is important to better probe the interface between personal conduct and the wider context when anticipating the design, use and interpretation of new technologies (Giddens 1984; Sewell 1992; Van Den Eede et al. 2015) (see also Section 6.3.5).

6.3.3 Where to start imagining: a matrix for structuring possible forms of mediation

Anticipating mediation effects through moral imagination required us to account for the 'frames of reference' of the actors involved in the imagination process, because only particular mediations will come to the forefront and they will be categorised as confirmative or disruptive mediation. One way to do this, as a preliminary, was to include an exploratory literature review about prominent problems in debates about the system and specifically about GM crop applications, as the dilemmas and tensions found there can hint at regime elements that are highly institutionalised or contested. As an illustration, the debate about (GM crops within) EU agriculture involves extensive discussion about vegetable protein dependency, loss of biodiversity, scale economies, private sector-driven institutions and vertically coordinated supply chains as prominent problems (Chapters 3, 4 and 5). On this basis, several mediations could be defined.

Another, perhaps complementary, opportunity to anticipate mediation effects of a technology-in-use can be found in participatory approaches - where actors with opposing points of view are brought together (e.g. Avelino and Rotmans 2009; Bos and Grin 2012; Verbeek 2006b). Through

debate and exchange of viewpoints, established stances may get challenged while blind spots appear. This is helpful in identifying the confirmative mediations of the technology design.

At this moment, however, mediation theory is strong as a theory, but less as a methodology, in the sense that there is not really a format available determining how to structure the anticipation of (un)intended forms of technological meditation, or how to make a moral assessment of the mediations involved (see also Section 6.5). Therefore, in order to structure our estimation of technological mediation effects in the (Farmer) - GM crops - (Agricultural world) relationship, we have adapted a matrix developed by Swierstra and Waelbers (2012) which explores how technologies affect the reasons behind people's moral action. This matrix was taken as a heuristic to guide our attention towards certain forms of mediation, because it offers a hands-on structure to analyse how technology may affect values, standards and expectations - thus mediating human perception in a hermeneutic way. They argue that these altered perceptions about the world can then also change actual human actions, by changing the reasons or motives to act in a particular way - mediating human action in a pragmatic way.

In the original matrix, three types of reasons upon which people base their practical judgements are included, namely: What 'is' the situation? What 'can' one do? And what 'ought' one to do, given this situation and these possibilities? Each of these three types of reasons is represented in a column of the matrix as "technologies mediate what we believe to be the case ["IS"], what we believe to be possible ["CAN"] and what we believe to be desirable ["OUGHT"]. And by mediating these beliefs, technology mediates the actions based upon these beliefs" (Swierstra and Waelbers 2012 pg. 160). The matrix includes these technologically mediated 'is-, can-, and ought-beliefs' as being morally relevant (represented in the rows of the matrix) by looking, first of all, at who is affected by an actor's (technologically mediated) practical choices (which parties; referred to as a stakeholder), secondly by looking at the consequences of (in)action, and, finally, by looking at the effect upon conceptions of a good life. The original matrix also applies a structure of amplification and reduction in transforming perceptions, because technologies can make new aspects of reality visible, but also sometimes hide part of reality (in the 'IS' dimension). Technologies can generate new practical affordances, but also rule out existing ones (in the 'CAN' dimension). And technologies can mediate our ideas on what we ought to do, so they can make us pursue certain actions or refrain from others (in the 'OUGHT' dimension).

This matrix was our starting point for further analysis, but in search of a more conceptual basis to structure the mediation analysis, we introduced the (Human) - Technology - (World) relationship more explicitly, which is key in mediation theory. For this, we maintained the formulated

interrelationship in the original matrix between IS, CAN and OUGHT, by assuming that technologically mediated perceptions of what 'is' and what 'can' can each have an influence on the norm (what 'ought'). The third column is therefore related to the first and second columns. We then re-categorised the rows along the postphenomenological perspective in mediation theory, by joining the perspectives 'stakeholders' and 'consequences' together in a more overall presentation of *'the world'* as mediated by the technology. We did so because, in the original matrix, a stakeholder is specifically defined as someone who suffers or enjoys the consequences of our (in)action, but, in mediation theory, subject and technology are constitutive of each other (Section 6.2). This means that technology cannot 'exert its effects' upon someone. Only technologically mediated subjects exist. This adaptation to the original was not a vast task, as Swierstra and Waelbers (2012) have already urged that the rows 'stakeholders' and 'consequences' "closely hang together and mirror each other" (pg. 162) because morally relevant consequences are defined in terms of whether they affect stakeholders, and stakeholders are those people who suffer or enjoy the consequences. The third row in the original matrix included perceptions of a good life, including how technologies alter our perceptions of the place of humans within the world ("IS"), how technologies create and limit our options to live what we believe to be a good life ("CAN"), and how technologies help to co-shape what we believe to be virtuous ("OUGHT"). More explicitly in relation to the (Human)- Technology - (World) relationship within mediation theory, this category was reinterpreted as the morally *mediated subject* that gets constituted. This row thus anticipates how humans (in our case study the farmers) are present in the technologically disclosed world (and vice versa), which is stipulated and estimated in the first row of our matrix. This reciprocity between the first row (mediated world) and the second row (mediated subject) in the revised matrix is nicely covered in Ihde's (1990) wording that "for every change in a 'world' there is a correspondent change in the 'human' / "for every change in what is seen [...] there is a noticeable change in how [...] it is seen" (pg. 79)

6.3.4 The adjusted matrix: anticipating the moral significance of the (Farmer) - GM crops - (Agricultural World) relationship

The new matrix is an improvement for bringing mediation theory into practice because: (1) the matrix now better mirrors the mutual interrelationship between the technologically mediated subject (human) and object (world) in Verbeek's postphenomenology, and (2) the matrix identifies both hermeneutic and pragmatic mediations and their role in mediating norms. As such, the new matrix can be used to estimate the (Farmer) - Technology - (Agricultural World) relationship that GM crops mediate within their current mono-stability, based upon the six

elements present in the new matrix. This shows how a technology can mediate 'the way in which the world is present to us' and 'how we are present within that world' (Figure 6.2):

- World/IS: Technology mediates perceptions of the world: technology can bring actors (human and non-human stakeholders) to the fore-/background.
- World/CAN: Technology mediates opportunities and affordances: technologies can increase/decrease our opportunities and affordances, bring about new practical options or rule out existing ones.
- World/OUGHT: Technology mediates rights, duties and responsibilities (i.e. norms): technology helps to create new norms or make existing norms become contested.
- Human/IS: Technology mediates users' perceived position in the world.
- Human/CAN: Technology mediates users' perceived role in the world.
- Human/OUGHT: Technology mediates ideas about a virtuous life.

The matrix in Figure 6.2 illustrates each of these six forms of meditation for the (Farmer) - GM crops - (Agricultural World) relationship along a format of confirmative and disruptive mediation. This matrix is self-explanatory, but we will briefly explain the six forms of mediation with a few examples.

In the World/IS form of mediation, it is estimated who or what the new technology brings to the fore-/background. For example, our natural definition of 'a biological species' is challenged by the development of transgenic GM crops (disruptive); while these crops also increase awareness of a strong vegetable protein dependency within EU agriculture (confirmative).

In the World/CAN form of mediation, it is estimated which possibilities or affordances the new technology generates or decreases, leading to new practical options or the ruling out of existing ones. For example, GM crops introduce new opportunities for private ownership in agriculture, or new options for genetic determinism in crop production (disruptive); while GM crops also re-afford a focus on productivity in agriculture and the humanist belief that nature is open to revision (confirmative).

	What is the situation		What can one do?		What ought one do?	
WORLD	**Technology mediates perception of the world**		**Technology mediates opportunities and affordances**		**Technology mediates rights, duties and responsibilities**	
	DISRUPTIVE MEDIATION	**CONFIRMATIVE MEDIATION**	**DISRUPTIVE MEDIATION**	**CONFIRMATIVE MEDIATION**	**DISRUPTIVE MEDIATION**	**CONFIRMATIVE MEDIATION**
	Interpretation of a biological species.[1] GMOs can cross species boundaries (e.g. transgenesis), so species characteristics may no longer be defined just by a strict pattern of intersecting lines. **Presenting nature as a lego building box.**[2] GMOs bring forward a mechanical perception of nature; where nature offers the bricks and pieces that can be combined along human ambition and intent. **GM 'seed plus herbicide' is a new entity**.[3] Coupled sales of GM seed together with the herbicide create a new determinant of social interaction: 'GM seed *plus* herbicide'.	**Nature as knowledgeable**[4] GMOs make us aware that nature within today's agricultural practices is conceived of as being knowledgeable & manipulative. **Soy imports as evident reality**.[5] GMOs increase awareness of a strong vegetable protein dependency within EU agriculture. **F1-generation seeds**.[6] GMOs increase awareness of standard usage of F1-generation seeds for certain crops; favoured for their greater fit, but segregated so no seed savings.	**Crops as patentable.**[7] GMOs are a new opportunity for private ownership in agriculture. **Genetic determinism**. GMOs present a new form of genetic determinism in crop production (where a crop is defined by its genetic constellation). **Decoupling with nature**. GMOs are a new opportunity to decouple agriculture from nature's genetic limits and to re-create nature. Knowing the world merges with creating it. **Next generation technocratic solutions**.[8] GMOs create new opportunities with regard to food security, climate change, chemical use in crop production, etc.	**Nature as a resource**. GMOs use nature as a resource for innovation (e.g. delivers resistances). **Humanist belief**.[9] GMOs are another practical affordance for the (humanist) belief that nature is open to revision. **Economic growth paradigm**. GMOs present piecemeal, economically viable solutions for environmental problems. **Current affordances**.[10] The practical affordances of GMOs reinforce a focus on productivity, lowering food prices and decreasing the cost of farming within agricultural practice. GMOs also standardise scale increase and monocultures in agriculture.	**Control(ability)**.[11] GMOs suggest the norm for control and controllability in crop production. **Genetic determinism**. GMOs suggest the norm for genetic determinism in crop production. **Easy-going**.[12] GMOs suggest the norm for 'how easy' farming or food production is, or can be. ***Expecting* a good harvest becomes *choosing* a good harvest**. GMOs present failed harvests more in terms of the ('wrong') technology choice by farmers. GMOs thereby decrease the right to 'bad luck' or the right not to (try to) control everything in crop production.	**Use of technology**.[13] GMOs reinforce the use of technology to obtain food security (e.g. re-present food security/hunger as a productivity-problem). **Return of investments**.[14] GMOs reinforce the right for a return on investments in agricultural innovation. **Surpassing limits**.[15] GMOs reinforce the responsibility and duty to maximise control; and to maximise productivity.
HUMAN (FARMER)	**Technology mediates users' position in the world**		**Technology mediates users' role in the world**		**Technology mediates ideas about a virtuous life**	
	DISRUPTIVE MEDIATION	**CONFIRMATIVE MEDIATION**	**DISRUPTIVE MEDIATION**	**CONFIRMATIVE MEDIATION**	**DISRUPTIVE MEDIATION**	**CONFIRMATIVE MEDIATION**
	Proletarianised farmer.[16] Because of patents on GM crops the farmer is no longer the owner of the seeds, and has no direct access to the innovation knowledge.	**The farmer in a chain organisation**.[17] Actor in a globalised network of resource flows. Also actor in a network of crop innovation (buyer of seeds; specialised R&D centres).	**The farmer as a technology chooser**.[18] GMOs present farming as a practice of 'pick and choose' technology (e.g. over other farming skills). **Directing the farmer**. Many GMOs afford to change the act of farming, with specificity of traits (e.g. herbicide resistance; crop rotation).	**Farmer as executor**.[19] GMOs reinforce an executive role for farmers in crop production: no innovator role (done in R&D centre). **Farmer's replacement in the production process**. GMOs reinforce this replacement (e.g. no tillage but herbicide spraying).	**Farmers in relation to control**.[20] GMOs present a norm for increased control by farmers in crop production (with herbicide-resistance for example) and over farmers (e.g. proletarianisation).	**Entrepreneurial agriculture**. GMOs posit farming as standardisation; portrayed only as something production-related. **Farmers in a network**.[21] GMOs posit farmers as a producer of commodities and bulk products. They also posit farmers as a link in a segmented process.

Figure 6.2. The matrix: estimated forms of technological mediation of GM crops within their mono-stability within EU agriculture today (previous page). The matrix shows possible mediations of human interpretation and practice that GM crops mediate along a (Farmer) - GM crops - (Agricultural World) relationship, based upon the mediation theory of Verbeek. Note that the estimated practical affordances and user's perceived role (both in the 'CAN' dimension) are exemplified for GM crops with agricultural traits. In the table, the numbers are references to illustrate this form of mediation. [1]De Krom et al. 2014; Midgley 2000. [2]Pellizzoni 2010; Smits 2006. [3]Pechlaner 2010. [4] Hendry 2002. [5]Klümper and Qaim 2014. [6]Lim 2014. [7]Pechlaner 2012. [8]Mannion and Morse 2013; Brookes and Barfoot 2013. [9]Pellizzoni 2011. [10]Otero 2012. [11]Pellizzoni 2010. [12]EuropaBio 2015. [13]Dibden et al. 2013. [14]Pechlaner 2010; Vanloqueren and Baret 2009. [15]James 2014. [16]Lemmens 2014. [17]Inghelbrecht et al. 2014b; Vanloqueren and Baret 2009. [18]Price 2014. [19]Lemmens 2014; Vanloqueren and Baret 2009. [20] Ruivenkamp et al. 2008. [21]Inghelbrecht et al. 2015.

In the World/OUGHT forms of mediation, it is estimated how the new technology creates new norms or makes existing norms become contested. GM crops, for example, change the norm on expecting a good harvest (this becomes choosing a good harvest with 'the right' technology choice) which increasingly diminishes e.g. the right to 'bad luck' in crop production (disruptive). On the other hand, GM crops also reinforce the responsibility and duty to maximise control and productivity in agriculture (confirmative).

In the Human/IS forms of mediation, it is estimated how the new technology positions its users in the world. GM crops, for example, posit a proletarianised farmer (where the farmer is no longer owner of the seeds and does not have direct access to the innovation knowledge). On the other hand, GM crops reinforce a position with the farmer as an actor in a globalised network of resource flows, and part of a network of crop innovation (confirmative).

In the Human/CAN forms of mediation, it is estimated what role the new technology ascribes to its users. GM crops, for example, present farming as a practice of 'pick and choose' technology (e.g. over other farming skills) (disruptive); while GM crops also reinforce an executive role for farmers in crop production, where the innovator role is taken up by specialised R&D centres (confirmative).

In the Human/OUGHT form of mediation, it is estimated how the new technology mediates ideas about a virtuous life. As GM crops, for example, present increased control *by* farmers in the crop production process, and *over* farmers (e.g. proletarianisation), ideas about what is and should be good farming and good agriculture may shift (disruptive). On the other hand, GM crops reinforce the norm on entrepreneurial agriculture and an overall perception that agriculture is the producer of commodities and bulk products, with farmers being a link in a segmented process of food production (confirmative).

We can conclude that the matrix of Swierstra and Waelbers (2012) was a valuable heuristic to guide our attention to certain forms of technological mediation when estimating possible mediations of GM crops within their current mono-stability. The 'IS', 'CAN' and 'OUGHT' subdivision was particularly valuable in structuring forms of technological mediation, as well as their consistent attention to both amplification and reduction by technological mediation. En route, however, it turned out to be confusing that the respective categories of 'stakeholders', 'consequences' and 'a good life' in the original matrix were largely unexplained in their paper, and that these were illustrated with rather scattered, and sometimes very individualised, examples. This is also one of the reasons why we decided to tighten the conceptual link between the original matrix and Verbeek's mediation theory. In fact, we believe that there is a mutual benefit, in the sense that mediation theory currently lacks a structured approach to moral imagination, which is now offered by the adjusted matrix; while the matrix of Swierstra and Waelbers can benefit from a closer link with postphenomenology in mediation theory.

6.3.5 A socio-political dimension in mediation theory

It was an observation that mediation theory is very valuable for instigating active engagement with technologies (Verbeek 2013), but it currently lacks specific consideration of the macro-perceptual influences on the design, interpretation, and appropriation of new technologies (Kaplan 2009). One can introduce such a macro-perceptual dimension within the existential micro-perceptual sphere of technological mediation, by including the systemic structuring of individuals within the analysis (along the sociotechnical regime concept in the MLP; Chapter 5). This opens a new perspective on mediation theory that constructively addresses several of the existing critiques on mediation theory (e.g. Kaplan 2009; Rao et al. 2015).

Namely, human beings are always part of a society and, therefore, co-determined by the 'set of rules' in place within a sociotechnical system such as EU agriculture. These rules will automatically co-structure actors' perceptions about what is 'right', 'normal', or 'wrong', and these incumbent rules will also influence how an individual will interpret, assess, design, and appropriate new technologies. An 'ought' dimension is therefore also present *within* the 'is' and 'can' dimensions. Emphasis should therefore be placed on the mutual relationships between the IS, CAN, and OUGHT dimensions. Technological mediation is therefore also cultural, social and political (Kaplan 2009). We have as little autonomy in terms of technology as we have in relation to the structures in place, while at the same time we are not completely (pre)determined by either of them. A socio-political dimension cannot, therefore, be separated from this hermeneutical framework.

All this goes to show that technological mediation analyses should include a systemic view in the design and anticipation of the AB hybrid, as both the materialising values and the human intentionality should be analysed within an overall context of systemic structuration. This develops the view that technology practices are not just structured by the incumbent regime (such as in the Critical Theory of Feenberg for example; Feenberg 1991, 2002, 2005), but also actively directed by a technological intentionally (such as in mediation theory). In short, this results in an extended framework for technological mediation where human-technology associations are acknowledged to be actively directed by both the incumbent regime structures and by technological intentionalities, without being completely predetermined by either of them.

6.4 A mono-stable reality: the moral significance of GM crops in their current use context

Based upon this technological mediation analysis, we can shed new light upon the ongoing debate about GM crop applications within the EU. This following discussion is structured along the respective confirmative and disruptive mediations identified in the matrix in Figure 6.2.

Parts of the ongoing debate can be considered as a result of confirmative mediations of GM crops, because emerging technologies can make moral routines more visible, or increase awareness about them. In the wording of Swierstra and Rip (2007), emerging technologies can take moral routines out of their self-evident invisibility and by so doing, change 'cold' morality into 'hot' ethics again. This means that moral assumptions or moral routines about what is considered good to perform, or about what should (not) be done, may once again become part of a reflexive debate about what is actually 'good' or 'bad' (Swierstra et al. 2009).

With a few examples from Figure 6.2, we can illustrate how GM crops might have taken some moral routines out of their self-evident invisibility and made these 'hot' ethics once again through their confirmative mediation. For example:

- Private funding of agricultural innovation has been an ongoing process since the 1970s, but with the development of GM crop applications, specialised R&D centres, private capital investments, and the associated executive role of farmers in crop production has become more visible.
- GM crops also reaffirm technocratic problem framings in relation to, for example, food security or climate change, and by so doing can take this moral routine out of their self-evident invisibility again. That GM crops, then, are blamed for holding back socio-political

measures to co-address these problems can, in this respect, be seen as a matter of confirmative mediation.

- GM crop applications, and the discussion about them, also make us more aware that ethical principles to resist particular products of modernisation, science and technology may prevail in the private sphere within EU society, but not in the public sphere. There, scientific argumentation is strongly prioritised, as a means to objectify political decisions. GM crop applications can therefore increase awareness of the consequences of a strongly science-led political decision making within EU democracy, making the institutionalised role of science within society more of a 'hot' ethics issue again (Chapter 7).
- GM crops also make us more aware of the prefix that generating empowerment in relation to (this) technology is often interpreted as offering a particular set of options (by labelling in this particular case). GM crops can thereby increase awareness that freedom of choice, by means of offering options, can be seen as a sort of trade-off for proceeding with technological innovation in general.
- …

These findings show that large parts of the ongoing debate about GM crop applications within the EU can be understood as (an attempt) to debate how we have organised EU society today. This is an important conclusion, because it legitimises this debate from the perspective of the technology itself, while resistance against the confirmative conduct of GM crops is often repelled by proponents as a critique that is not just applicable to this specific technology. Instead, it is the specific technological amplifications and reductions in GM crops, within their current mono-stability, that brings these issues to the forefront. Accordingly, this insight provides an opportunity to exchange the current 'battle for the best framing' of the problem with GM crops, to a public consideration (perhaps reconsideration) of what 'our' societal norms and priorities should be (Goorden 2004; Verbeek 2014).

In addition to these confirmative mediations, parts of the EU debate about GM crops result from their disruptive conduct. This directly delivers 'hot' ethics. For example, with GM crops:

- 'bad luck' in the crop production process can increasingly become a matter of technology choice by the farmer. Expecting a good harvest may then become choosing a good harvest and GM crops may therefore stigmatise (intentionally or unintentionally) a labour intensive, low production type of agriculture that values harvests differently. This directly delivers

'hot' ethics, because these technological amplifications and reductions can create a 'strange but true' image for organic farming or urban agriculture, for example.

- GM crops also introduce 'hot' ethics by directly interfering with our definition of 'a biological species' which is now based on a strict pattern of intersecting lines. However, with the possibility of transgenes the definition of 'a species' may become more of a political definition in the near future.
- GM crops also introduce 'hot' ethics by introducing a norm of genetic determinism in crop production, instead of mainly presenting agriculture as being unpredictable and uncontrollable as it involves living beings and is exposed to varying circumstances such as pest infections or weather circumstances.
- …

Overall, this analysis of technological mediation explains the strong opposition to GM crops in the EU in terms of the technological amplifications and reductions within their current mono-stability. It would therefore be too simplistic to argue that it is just ideological arguments that are at the basis of this opposition. Rather, the analysis makes clear how ethical concerns about agricultural practices have co-evolved with the material development of GM crops, in terms of both confirmative and disruptive mediation, in either intentional or unintentional ways. This is, in fact, and added value of combining mediation theory with Swierstra's view on techno-moral change, as the established user-practice(s) with this technology can be understood in terms of both the directedness of the technology and the regime structures in place. On this basis, the ongoing GM debate can be understood as a consequence of the new concerns that these applications unveil, by making 'cold' morality 'hot' ethics again and as a consequence of the direct introduction of several 'hot' ethics issues.

Speaking at a more conceptual level, our approach may be seen as an extension of Verbeek's work, because a widespread critique on mediation theory refers to its one-sided focus on new, and thus disruptive, mediations that only anticipate the 'hot ethics' of the new technology (see e.g. Feenberg 2009; Kaplan 2009; Rao et al. 2015; Van Den Eede 2011;Van Den Eede et al. 2015; Verbeek 2012). What our approach adds, through the concept of confirmative mediation, is at least a conceptual basis to anticipate and include those instances of 'cold morality' that are part of a sociotechnical system. This is important, as illustrated by the introduction of this incremental innovation within EU agriculture, because cold moralities may be heated up again, to the point where they become 'hot' ethics issues.

6.5 A multi-stability of GM crops within EU agriculture

So far, our technological mediation analysis of GM crops has shown the importance of establishing a reflexive attitude in the design of new GM crop applications. This involves paying explicit attention to the technological intentionality of a GM crop, as well as to the human intentionality present in the user context. Otherwise, new GM crop designs are likely to be trapped again within the same mono-stability and mono-identity that is in place within EU agriculture today.

However, this brings us systematically to the question of how to design for technological mediation and unfortunately, mediation theory is not yet strong as a methodology. Verbeek (2006b, 2011) only emphasises the establishment of a connection between the context of design and the context of use to take responsibility for the mediating role of the new technology, but the proposed methods are largely unexplored. He suggests the concept of moral imagination (as applied and expanded earlier); secondly, he proposes augmenting constructive technology assessment where the technology design integrates assessment of its users during the technology's development, with the aim of reaching consensus about the design of the technology, which is constructively assessed (i.e. during its design). The third method he proposes is scenario-oriented approaches or virtual reality set-ups. Certainly, if the anticipation of technological meditation effects is not placed explicitly and systematically on the agenda when designing or authorising new technology, the mediating role of technology is likely to remain hidden (Verbeek 2011).

This section will illustrate some variables at play when designing GM crops with a particular crop/trait combination, but certainly not all. Technological mediation effects can, in fact, never fully be anticipated or known in advance. There will always be unintended mediations involved, for the simple reason that technology only bears meaning within the network-of-use that is weaved around the technology, which can never be fully anticipated (Van de Poel and Verbeek 2006). This section should therefore be read as a philosophy-in-practice.

Technological mediation: AB rather than A + B

To explicitly introduce both technological and human intentionality as variables in the design practices of a new GM crop, our starting point is Verbeek's (2011) suggestion to reflect upon both the script logic and the user logic when designing for technological mediation:

- the script logic focuses on the impact of the technology on user behaviour. It is thereby important to reflect upon which norms and values are embodied ("materialised") and which ones are excluded from the design.
- the user logic focuses on how the technology is interpreted and appropriated by its users. It is therefore important to focus on possible interpretations and appropriations by users, and to anticipate the various possible use contexts (see the glossary on script and user logic).

This approach can be seen as a proactive version of the matrix that is presented in Section 6.3. Yet, as already mentioned there, such an exercise is inevitably blinded by the limits of human imagination. This is why we argue that investigating the script and user logic should occur iteratively, empirically and must be formulated as multi-actor processes through, for example, scenario-based approaches or virtual reality set-ups (Verbeek 2011). In such exercises, attention should be given to various contexts of use and to how, in each of them, the GM crop 'in use' could mediate human interpretation or human action.
Within the constraints of an academic chapter, we can only hint at some points of attention here, thereby drawing on our own moral imagination.

A first point is that we should be careful with the distinction made between the script logic and the user logic. Although such a distinction may be possible on an analytical level, and probably even necessary on a practical level, making the distinction automatically presents technological mediation as a mere sum of script and user logic (A + B), while technological mediations, as we have argued at length, are brought about by the hybrid (AB) actor that acts. However, a certain 'disconnection' is required in analytic terms to enable anticipation, and a reflexive approach, towards the directedness of the script logic, the user logics and the emergent human-technology association. This inevitably points to a deficiency in analytical approach: in order to anticipate, one needs to adopt an analytical, reflexive approach (A + B). In adopting such an attitude, however, this approach prevents perfect anticipation because mediation only works through hybridity (AB) (Rao et al. 2015; Verbeek 2011; Whyte 2015). As we will further argue, this sense of imperfection should not stop us from trying to anticipate the eventual mediations, as it allows us to get a much closer grip on a way of life when discussing the introduction of a new technology, compared to the dichotomously Yes/No framed question of mere acceptability.

Second, anticipating the script logic by means of moral imagination is possible to a limited extent, as it is straightforward to think about what a GM trait 'can do'. In very general terms, GM traits such as herbicide-resistance or fungal-resistance, for example, materialise appropriationism, as they replace elements in the natural production process with industrial activities. A GM trait such

as an omega-three enrichment materialises substitutionism by gradually replacing agricultural end products with industrial ones (Pechlaner 2010). GM traits such as drought-resistance, crop rotation or capturing CO_2 materialise ecological modernisation; the belief that environmental problems can be solved without altering the structure of our production system (Hajer 1995).

However, the interpretation and appropriation of a GM trait can vary extensively, which constitutes very different meanings and identities for the GM technology, as the following example illustrates:

- A GM trait of crop rotation, where crops only grow when a particular rotation has been performed (e.g. because certain nutrients only become available in the soil after cultivating a particular crop) can seem at first glance 'morally benign' (can there be a better way to stimulate diversified farming?) and it may seem obvious to use this crop in any type of farming practice (as crop rotation is, for example, also part of the ideology of agro-ecological farming). Yet, from a perspective of mediation theory, it remains important to reflect on the strong pragmatic intentionality involved, as the trait has a strong inclination towards changing the act of farming. Designers should also realise that this trait foregrounds a particular, standardised view on biodiversity, as all these rotations will once again include that same set of crops. This standardisation may, in turn, conflict with other more encompassing interpretations of biodiversity and may further reduce a farmer's role to becoming purely an executor in crop production.
- However, this does not imply that such a 'crop rotation' trait should not be designed; our anticipation only points to the importance of taking into account the possible mediations when discussing the design of such a trait; and anticipating the possible script logic accordingly. It may, for instance, lead to abstention from promoting this GM crop in an agro-ecological type of farming, as the materialised view on biodiversity might be too technocratic for some of agro-ecology's core principles.

Third, anticipating the user logic by means of moral imagination proves to be even more difficult, as the appropriation and interpretation of the new 'crop plus trait' combination involves so many actors (in crop innovation, crop production, crop processing and crop consumption) that it is hard to imagine the user logic from scratch. Nevertheless, anticipating possible user contexts (as multi-actor processes) remains crucial, as it may lead to adaptations to the technology-in-design.

- For example, with the trait of crop rotation, designers may explicitly opt for crops that require a particular expertise to cultivate, with the intention of stimulating collaboration between farmers or to reintroduce more of an inventors' role for the farmer in this crop

production process. Designers may also try to organise farmers with that particular expertise in a more community-based typology, etc. In set-ups such as this, where it is anticipated how a farmer might understand his role in the crop production process, or how it might change his perception of biodiversity, for example, a more empowered role for the farmer in cultivating this GM crop may be realised.

Although GM crops are, in essence, an agricultural innovation, these technology applications do not only affect farmers' interpretations.

- For example, when GM crops suggest 'how easy' and 'in control' farming practices are, this may affect the overall meaning of the farmers' craftsmanship within society. It can affect the societal perception of organic farming products, for example (e.g. why do these 'want' a lower productivity?); or GM crops can even change the level of willingness to compensate farmers for economic loss due to reduced or failed harvests (e.g. considering it an own responsibility not to use a technology).
- Or with a specific agricultural trait, such as crop rotation, the societal interpretation of what biodiversity is, or how biodiversity should be practiced, may change.

Agricultural innovations may also directly mediate interpretations and actions beyond the farming context (e.g. when they do not have an agro-economic trait). An omega-three enriched GM canola, to give an example, may influence several societal interpretations and not affect the act of farming so much directly:

- For example, processing an omega-three enriched GM crop in food products can influence the societal interpretation of the role of dietary supplements in food; it can stimulate perceptions of 'food as medicine' or it may label cardiovascular diseases perhaps as 'controllable, luxury problems' - which may, in turn, change the perceived level of human accountability for these diseases. A person with a cardiovascular disease may, perhaps even more than is already the case, be seen as individually responsible for his disease.

A useful step forward

No matter how provisional or imperfectly the anticipation of forms of technological mediation can proceed, we are convinced that this 'forward thinking' is a useful step towards bringing the discussion about GM crops nearer to its essence: to shift the focus from a dichotomous discourse of whether or not to accept a technology, towards the question of how technologies shape and participate in our way of life. The issue, then, is no longer whether to accept GM crops, but whether

to accept the forms of technological mediation involved. To illustrate this in relation to the above examples, discussion should involve questions such as whether a technologically mediated view on biodiversity is acceptable and desirable within EU agriculture; or whether a technologically mediated remedy for certain cardiovascular diseases, at the possible cost of the inclusion of consumption patterns in the diagnostics, is acceptable or desirable for society. Certainly, such questions are of a political nature, touching upon the question of a good life and how we have, or want to, organise life within EU society today. This is exactly what we gain from the mediation approach, because in assessing the impact of the mediating capacities of a technology in its use context, the focus shifts from a technocratic assessment of the (economic) gains and losses of a technology (e.g. Apel 2010; Miller 2010), towards the fundamentally socio-political question of how technology applications help to shape human interpretation and human action.

Implications for the design and authorisation of new GM crops

This all can be contrasted with the simple so-called A + B approach in which GM crops are currently designed, and EU authorised (see Chapter 2). Being, first of all in terms of the A component, the GM crop, even without paying attention to its technological intentionality (Section 6.1). Then, in a second step as an add-on, individual freedom of choice is granted by means of a GM label or co-existence measures (the B component). As should be clear by now, such a mere ad-hoc combining of technological and human intentionality cannot anticipate or design for technological mediation effects in a good way. Rather, a design of sociotechnical practices around GM crops should be pursued, which involves the proposed multi-actor processes, empirical tools and a form of iterative probing (Van Den Eede 2011) where the context of design is closely interrelated with the context of use, with lots of feedback loops, to actually create an AB actor iteratively (rather than an A + B format).

This also means that GM crops are better not designed 'in isolation' from their user context – as is the case today - because then insufficient attention is paid to the appropriation of the crop. The above examples also illustrate that technological intentionality should not be overlooked. Neither can technological mediation result from technological intentionality alone. Technological mediation results from the composite human-technological intentionality of a GM crop-in-use, where the GM crop helps to define situations and agents because it affords specific opportunities for action or because it discloses 'the word' in a particular way, while the user context interprets and appropriates the affordances of the technology along its own perceptions and programs for action.

In Verbeek's logic, the anticipation exercise should be followed by "a moral assessment […] of all mediations involved […] a method of applied ethics, such as stakeholder analysis, could be used here, with four points of applications standing out: the *intended mediations* that are deliberately inscribed in the technology; the *implicit mediations* evoked by the design, in so far that they can be anticipated; the *forms of mediation* used [e.g. a persuasive or compelling directedness]; and the *eventual outcomes* of the technological mediation […] special attention should [also] be paid to the questions of what kind of mediated subject results from the intended mediations [e.g. what role is stipulated for the farmer] and what possibilities exist for human beings to co-design the impact of these mediations in their subjectivity" (Verbeek 2011 pg. 117-118).

However, how the moral assessment or the quality of the intended mediating effects will occur in society cannot be foreseen. There are rather different possibilities for a moral assessment that are strongly actor-dependent (Swierstra et al. 2009). For example, an actor can focus on the proposed intent of a resulting mediation. Here, the programmed crop rotation, for example, might be considered as valuable. One can also focus on the consequences of technological mediation, where the overall increase in biodiversity may then be valued.

This means that when designing for technological mediation, the moral assessment of intended mediations of a GM crop-in-use cannot be fully anticipated, or known. Instead it involves multi-actor processes, empirical means and iterative probing by combining the context of design with the context of use. However, the anticipation of technological mediation for a technology-in-design is essential, because technologies-in-use actively shape how we live our lives.

6.6 Conclusion

The technological mediation analysis in this chapter has estimated how the particular mediations of GM crops, within their current use context, can actively mediate human interpretation and human practice within EU agriculture (RQ5). This allowed us to explain how ethical concerns about agricultural practices have co-evolved alongside the material development of these crops, in terms of both confirmative and disruptive mediation. The mediation analysis also points to several elements and practices that may explain why the public debate about this technology evolves along a Yes/No framing, which provides important levers to complement the ongoing public debate about GM crops in the EU (RQ2), as we will discuss in Chapter 7.

The analysis also points to several regime elements that socially reproduce the systemic, sociotechnical lock-in under study (RQ1). For example, the external, absolutist view on (this)

technology that is institutionalised within EU society is an important regime element that socially reproduces the lock-in under study (Chapter 7). Moreover, by explaining that parts of the ongoing debate about these crops result from confirmative mediations, the mediation analysis helps to explain why this particular incremental innovation is such a highly contested one within EU society (RQ4) (in combination with the results in Chapter 5, showing the role of this technology in discursive battle).

Finally, as a more overall conclusion, we want to highlight that several political EU practices reinforce a strong externalist view on (this) technology - such as the current GM labelling standard; the crop based EU authorisation procedure of GM crops; and the process-based definition of a GMO that sweeps away different technological intentionality in different GM crops. One may therefore suggest that the current EU GM crop legislation might benefit from extending its current focus beyond the technology basis, and towards regulating and stimulating the design of the sociotechnical practices around GM crops instead (Chapter 8; see the glossary on sociotechnical practice around GM crops).

CHAPTER 7.

DISCUSSION: THE SOCIO-POLITICAL PROBLEM WITH GM CROPS

Crossing different perspectives.

CHAPTER 7.

DISCUSSION: THE SOCIO-POLITICAL PROBLEM WITH GM CROPS

"The aim of a discussion should not be victory, but progress." (Joseph Joubert)

This dissertation has two major objectives. The first objective is to characterise the systemic and socially reproduced nature of the lock-in for GM crop applications within EU agriculture. The second objective is to characterise, and if possible enhance, the ongoing debate about GM crops in the EU beyond a dichotomous Yes/No framing.

In order to reach these objectives, this discussion chapter will build on the insights gained in Chapters 2 to 6 (see also Figure 2.2, copied hereunder). First, we will further characterise the three discourses that were discussed in Chapters 3 and 4 in terms of their epistemic and de-/re-politicising nature. On this basis, we will urge that the current legislative formulation of the problem with GM crops along an 'A + B' format of scientifically proven safety *plus* individual freedom of choice, stipulates the 'wrong' socio-political problem with GM crops. Instead, we suggest focusing on problem structuring along a 'policy as learning' strategy and we discuss the new role for policy, science and gatekeepers in relation to this problem structuring in the other subsections of Section 7.1. In Section 7.2, we define the structural complexity of the lock-in by delineating key perceptions, practices and institutions that lead to the socially reproduced nature of this persistent problem. In Section 7.3, we summarise our findings about the EU debate on GM crops and explain why, despite their incremental nature, GM crops are so highly contested.

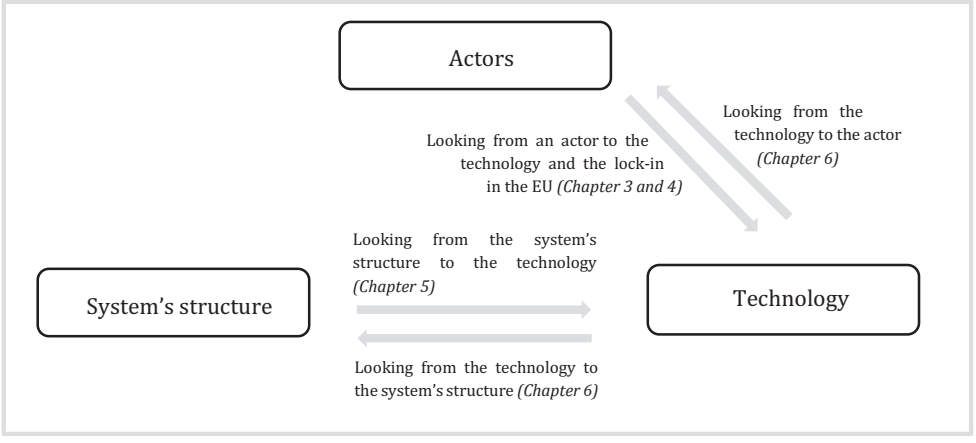


Figure 2.2 (repeated). Three angles to analyse the lock-in for GM crop applications within EU agriculture.

7.1 The 'wrong' socio-political problem with GM crops

7.1.1 Discursive struggle over scientific facts

Chapter 3 has defined multiple discourses that shape the discursive space for GM crop applications in the EU from an industry perspective: (i) GMIs as an agricultural payoff; (ii) GMIs as a marketing threat; and (iii) non-GM crops as a preset end goal. These three discourses are not mutually exclusive, in the sense that they have thematic congruence, as conceptualised in the structuring arena in Chapter 4. However, these discourses are incompatible because of a different epistemic status and their different way of de-politicising or re-politicising the problem at stake (as we will discuss here).

Different epistemic status in the three discourses

The three identified discourses have a different epistemic status or a different knowledge-basis for defining 'the problem' with GM crops (Humphreys 2009). The first discourse 'GMI as an agricultural payoff' strongly relies on knowledge and the truth or falsity of any claim that is made by any actor. The second discourse 'GMIs as a marketing threat' has a strong desire for scientific consensus, but it strongly holds others responsible for that. The third discourse 'non-GM crops as a preset end goal' has a stronger ideological or moral basis, with perceptions of what is good or bad, desirable or undesirable, and these moral claims cannot be answered with 'true' or 'false' (Humphreys 2009).

Also, the perceptions of what is acceptable 'non-knowledge' differ in these discourses, as each discourse has a different way of incorporating, and reacting to, unknown and unforeseeable risks and effects in a scientific set-up. Böschen et al. (2010) refer to these competing evaluations of what is known and not known between social actors as the existence of different 'cultures of non-knowledge' when generating scientific knowledge - in this case about GM crops (see also the glossary on cultures of non-knowledge).
The first discourse adheres to a control-oriented culture of non-knowledge, which has an epistemic focus on control of the experimental set-up and on generating 'hard facts' (a reductive approach). The second discourse has a strong desire for scientific consensus, but does not really specify its perception on scientific uncertainty. Instead, it holds the scientific community responsible for that. The third discourse adheres to a complexity-oriented culture of non-knowledge, which is characterised by exploratory scientific set-ups that are very much open to

unanticipated effects. These set-ups try to be as close as possible to real life settings (a holistic approach).

This means that there are multiple interpretations (or cultures) of non-knowledge amongst social actors, and that perceptions about what 'is' non-knowledge are rather multifaceted and have to be socially negotiated (Böschen et al. 2010). This creates a situation where "the competing perceptions of non-knowledge are adopted selectively by various social actor groups to pursue their respective political agendas" (pg. 793). Different non-knowledge claims are therefore politicised.

Taking scientific consensus as a starting point for any socio-political framing of 'the problem' with GM crops is consequently problematic, especially when the criteria for political deliberation on scientific uncertainty are unclear. However, this is the case today, as EFSA is disguising its subjective choices regarding appropriate methodologies and its framing of risks with GM crops, and the European Commission has systematically followed the opinions of EFSA in its draft authorisations (apart from one occasion) (Devos et al. 2014; Jensen and Sandøe, 2002; Jensen et al. 2003). This, in turn, leads to a scenario of 'EFSA science versus national science' and to a complete silencing of the role of politics in any scientific risk assessment (see also Section 2.2 Devos et al. 2014; Geelhoed 2014; Hristova 2013). It will therefore be important to (i) make explicit which culture(s) of non-knowledge is politically institutionalised (and prioritised) within the current EU political decision-making process on GM crops, and (ii) to politically recognise the presence, plurality and politicisation of non-knowledge claims (Böschen et al. 2010). Doing so, will require an extensive change compared to the depoliticised way of formulating Implementing Acts for new GM crop applications today, because these current practices inherently (try to) frame the problem as if there is a high level of agreement on the knowledge required and available to address the problem with GM crops.

A different politicising nature in the three discourses

The three discourses also have a different way of de-politicising or re-politicising the problem at stake (see also the glossary on de-politicisation). Stakeholders advocating the first discourse have a strong depoliticising discourse, marketing "GM food as a normal element of an inevitable, natural scientific and economic development serving the public interest. […] [this shifts] a politico-ideological debate about alternative technological futures *to dichotomies* such as science vs politics/ideology/fear, rationality vs emotionality, sound science vs junk science, etc. – with the effect of delegitimising any space for democratic debate about alternative technological futures"

(Maeseele et al. 2013 pg. 207, own emphasis in italics). The latter is precisely the intent of the third discourse. The discourse of 'non-GM crops as a preset end goal' puts forward alternative technological futures and creates conflict between them, "aimed at revealing the competing sets of assumptions, values, and interests underlying opposing responses to scientific uncertainty (such as corporate control, financial interests, technological progressivism, a large-scale, industrialised, energy- and capital-intensive agriculture, etc.)" (Maeseele et al. 2013 pg. 207). The third discourse therefore has a repoliticising nature, as it reintroduces new elements into the EU political environment on GM crops by putting forward new key questions, new ideologies and new approaches that are neither science-based nor technocratic, but which debate the very nature of society (De Krom et al. 2014; Maeseele 2011, 2013; Rosendal 2005, Skogstad 2011).

The widely diverse norms and values 'at play' in relation to GM crops have been acknowledged in the political framing of the problem with GM crops. This is by including individual freedom of choice as one of the cornerstones of the 'A + B' political basis in the EU GM crop legislation (see Chapter 2). However, ethical arguments and moral concerns are, as a result, legitimate within the individual private sphere rather than in the public sphere. Claims such as socio-economic concerns, public opinion, or preferences for a certain type of agriculture are largely excluded from the general decision-making process. This is because "the Commission tries to sideline the contestation of opposing views by appealing to the principles of science-based policy making" (Hristova 2013 pg. 123), and because the risk-based regulation, in itself, transfers certain (types of) arguments from the public to the private sphere. Hence, the fundamental idea is that "people are free to choose not to use GM products *for themselves*, but they must agree to live in a society where, as long as these products are not harmful to third parties and the environment, others can produce, sell, buy, and consume them if they wish. On this view, moral attitudes belong in the private sphere" (Jensen 2006 pg. 277, own emphasis in italics).
This automatically restricts the scope of conflict in the political decision-making process for GM crop applications (Swierstra and Rip 2007). A restriction that is moreover reinforced by the "pronounced tendency for public resistance to GM crops to be articulated in terms of risk even though, at the end of the day, it is about something else. This tendency strongly distorts the debate on GM crops" (Jensen 2006 pg. 278).

Altogether, then, the political framing of the problem with GM crops along an 'A+B' format, with presumed high levels of agreement on the knowledge available and required to address this problem, plus individual freedom of choice, presents the wrong type of problem in relation to ongoing societal (civil) and political concerns.

7.1.2 The 'wrong' socio-political problem with GM crops

Two key aspects stand out in the above characterisation of the political problem framing with GM crops in the EU.
First, up to the level of the European Commission, ongoing practices (try to) frame the problem as if there is a high level of agreement on the knowledge required and available to address this problem. Important elements to support this are (see also Section 2.2):

- The fact that the European Commission systematically follows the opinions of EFSA when formulating authorisation decisions for new GM crops. This keeps up appearances as to the universalism of science and it questions any meaningful distinction between scientific risk assessment and political risk management (Geelhoed 2014; Hristova 2013).
- The structural divide between the risk-assessment and the risk-management phase in the authorisation procedure creates the idea of a strict divide between the 'world of science' and the 'world of policy', adhering to a scenario where scientific facts are not at all political (Devos et al. 2014; Jensen et al. 2013).
- The strongly objectified interpretation of risk in the Commission's understanding of the precautionary principle also contributes to this. Although the European Commission is essentially a risk-management body that openly acknowledges that acceptable levels of risk are essentially a political decision (EC 2000), scientific uncertainty is also seen as a current lack of knowledge that can be addressed with further research (Myhr 2007).

Secondly, the high level of disagreement on the norms and values at play in relation to GM crops has been acknowledged in the political framing of the problem by emphasising freedom of choice. However,

- Moral arguments are transferred to the private sphere (Jensen 2006).
- Social concerns have not yet become part of the draft decisions of the European Commission.
- The strong emphasis on risk in the overall (evidence-based) regulatory procedure makes stakeholder involvement largely symbolic. This is because public actors put forward ideology-based viewpoints and ethical, socio-economic and other value-driven arguments which are difficult to verify under the current legislative procedure (Kastenhöfer 2011).

Therefore, in the political framing of the problem with GM crops, high levels of conflict about values and rights on GM crops are mitigated by trying to reach a *compromise on the means* to

enable a future consensus amongst strongly divided actors (Chapter 2). This compromise involves a science-based risk assessment where scientific consensus is taken as the basis for political decision making, in combination with offering freedom of choice *after* authorisation, as individual freedom with respect to GM is considered to be the most relevant value for all of the conflicting parties.

As a consequence, the general EU authorisation procedure for GM crops is mainly based on elite consultation, with little or only symbolic public participation, and there is a clear distinction made between lay people and experts, the latter having the task of depoliticising the conflict and 'objectifying' the problem (De Krom et al. 2014; Devos et al. 2014; Fisher 2015; Gottweis 2008; Hristova 2013; Kastenhöfer 2011; Maeseele 2009, 2013). This automatically restricts the scope of conflict within the political decision-making process (Swierstra and Rip 2007). On this basis, it seems that the problem formulation in the risk-based EU GM crop legislation puts forward a *moderately structured problem (means)* – especially as a result of the Commission's attempt to take political decisions without having to repoliticise every decision.

Namely, the political framing of the problem along an 'A + B' format acknowledges the low levels of agreement on the norms and values at stake, while stipulating high levels of agreement on the available and required knowledge. When relating this to the socio-political framing of problems in the work of Hisschemöller and Hoppe (1995) and Wesselink and Hoppe (2011), this seems to be a moderately structured problem in terms of means: (certain) policy elites seek to handle the value conflict on GM crops in a realistic, business-like way, along a policy strategy of accommodation (Figure 2.1, bottom left).

This compromise was supposed to enable national concerns to be incorporated through deliberation. However, in practice, the compromise was unable to achieve broad social or full political support. This is illustrated, for example, by the political impasse in the comitology at the level of Member States' risk managers; or by the resolutions voted in the European Parliament against draft authorisation decisions for new GM crops (while the Parliament has no official role in this authorisation process); or by the withdrawal of the authorisation of Amflora; and the GM potato war in Wetteren (see Chapters 1 and 2).

Science cannot structure every problem in the same way, and it is important to show which role is stipulated for science within a particular EU problem statement (Hisschemöller and Hoppe 1995; Wesselink and Hoppe 2011). Therefore, within our case-study setting, we can argue that the current legislative formulation of the problem with GM crops as a moderately structured

problem (means) along an 'A + B' format of scientifically proven safety and individual freedom of choice – and especially how it has been brought into practice (Section 2.2) - stipulates the 'wrong' socio-political problem with GM crops.

Some of its main difficulties are:

- The strong (factual) dissent about the environmental and health risks of GM crops. This is either because the actual level of agreement about the safety of GM crops is less than presumed, or because ideological arguments are (have to be) reframed scientifically to obtain a hearing in the political decision-making process (Jensen2006). However, this only results in a discussion about the facts while the normative debate remains deadlocked.
- The political impasse in the comitology to reach a qualified majority for or against the authorisation of new GM crops.
- The formal divide between the worlds of science and policy presents scientific facts as something neutral and non-political (only as matters of fact).
- The confidence of EFSA in the scientifically proven safety of GM crops is based on a particular culture of non-knowledge (with particular methodological preferences and assumptions) which is currently not specified and therefore not open for discussion. This denies the social and political assumptions underlying EFSA's assessments of scientific data and it grants no legitimacy to other cultures of non-knowledge.
- Public concerns and problem statements are not acknowledged within the general authorisation process: "public resistance to the use of GM crops has no effective channel in which to make itself heard. Instead of there being a public debate about the nature and causes of public attitudes, the resistance is forced into a risk regime in which the only possible demand is the demand for more safety" (Jensen 2006 pg. 279).
- Political, cultural, and other arguments about risk perceptions could be included in the decision-making process on GM crops, but this does not occur in practice (see also Chapter 2). A meaningful aspect of risk management is thereby lost, or denied.

For these reasons, the EU legislation on GM crops has been criticised by proponents as being politicised (e.g. Ammann 2014), while the overall risk-focus in the EU legislation, endorsed by certain types of practice, has been criticised as being depoliticised by others (e.g. Klika et al. 2013). Yet altogether, the higher level of abstraction in the EU GM crop legislation, in favour of scientific expertise, where certain types of arguments are transferred from the public to the private sphere (by granting freedom of choice), could not obtain broad social or full political support. Rather, the

compromise involves trade-offs about values which deeply divide actors, including values such as the substantial privatisation of EU agriculture, a loss of biodiversity, or the continued dependence on imports and external inputs.

Hisschemöller and Hoppe (1995) explain that such intractable controversies come into existence if the viewpoints of certain groups or interests are not taken seriously by policy makers, and that shifting to accommodation and compromise is often characterised by disconnecting the conflicting values from the specific problem situation (in this case, focusing on risk in order not to repoliticise every authorisation decision).
Therefore, instead of persevering in objectifying the socio-political problem at stake with GM crops, it might be better either (a) to use the peripheral openness towards non-scientific argumentation within the authorisation process to take into account the existing diversity of argumentations. If not, logical truths will remain the focus of future discussion while the actual debate remains deadlocked (see Section 7.1.4). (b) Or, it might be better to focus again on problem structuring along a strategy of 'policy as learning'. This involves a change, from framing the socio-political problem with GM crops as a depoliticised, moderately structured problem (means), towards framing it as a wicked problem, with a new role for policy, science and gatekeepers (as discussed in the next three sections). By doing so, the 'A + B' problem statement is, in itself, revised and redefined to incorporate more of the diversity in existing arguments, so as to obtain a broader social and political legitimacy.

7.1.3 A new role for policy

Politically framing this problem as a wicked problem, will require us to revise the objectifying role for science *in defining* the problem with GM crops and to take a more systemic perspective where both scientific and non-scientific considerations can find expression within the authorisation process for a GM crop. The 'A + B' problem statement is, in itself then, revised and redefined, in order to obtain a broader social and political legitimacy.
Yet, this is particularly challenging because "the classical political game will have to change profoundly […] To accept a role as process architect instead of a position as the final decision-maker is [still perceived as] risky, because many fear that the voters may not support the architects, but will favor the politicians who present themselves as leaders in substantial solutions" (In 't Veld pg. 344). Rather than providing the right answers (to the wrong questions), the role of the policy elite is here thus rephrased to asking the right questions and this form of leadership explicitly allows for expansion on the level of conflict over the issue.

How to switch the political decision-making process towards a wicked problem is a question for future research and not really addressed in this thesis. Here, we limit our contribution by referring to the conditions for successful problem structuring that Hisschemöller and Hoppe (1995) have presented and we make the link with our own work.

(1) The first condition for successful problem structuring is that many different actors are involved, including those with authority and power to make decisions. All of these actors need to "invest time so that the broad range of options, even those elements taken for granted, may become part of the discussion" (pg. 54). Based on the analyses in this dissertation, we can make this condition for successful problem structuring even stronger as it is particularly those elements often taken for granted that have to become part of the discussion. This is precisely the added value of formulating a systemic problem statement based on characterising the wicked problem as a systemic, socially reproduced negative side-effect of the existing regime elements within EU agriculture (RQ1).

(2) The second condition for successful problem structuring is that it should address real cases and reflect the experience of those involved. This condition suggests focusing on the very tangibility of the wicked problem rather than simply on the discursive dispute involved. In our case, this meant focusing on the lock-in as the problem, revealed by very real cases (such as the 'GM potato war', the recall of authorisations, or the 'Séralini affair') and the very real experiences of those involved. The latter is what we have done in Chapters 3 and 4 by not just considering the EU lock-in as 'a situation' with which agribusiness actors have to deal (looking at situational decision-making; Grint 2005). We have, instead, analysed how agribusiness actors reproduce the lock-in through their own daily practices and how these actors' specific practices co-create the technology-specific context for GM crops within EU agriculture (looking at situated decision-making, analysing how an actor creates legitimacy and authority for his own practices) (Grint 2005).

(3) The third condition for successful problem structuring is that at least some segments of the official policy elite start to interact with actors who have an alternative view of the problem. This means that a strong political will to engage in problem structuring is required.

(4) The fourth condition explains that final political decisions must not be taken before the problem structuring has produced new insights into the problem and its potential solutions. Based on the analyses in this dissertation, we add to this the importance of starting from a systemic view on the problem during the structuring process, because this includes the normalised practices within a sociotechnical system (such as agriculture) in that structuring process.

7.1.4 A new role for science

Problem framing from a moderately structured problem (means), towards a wicked problem changes the role of science. It implies a change from the role of objectifying the problem - which assumes a one-to-one relationship between science and policy as two separate worlds (Devos et al. 2014) - towards a situation where the authority of science in defining the problem is secondary. The scientific question posed becomes as important as the scientific answer provided (van Buuren and Edelenbos 2004). We explain this below.

In a moderately structured problem (means), scientific experts have to objectify the problem and it is mainly expert knowledge that is valued in the political decision-making process (Hisschemöller et al. 2001). Elements that have not been taken into account in the scientific practice (i.e. the externalities of the scientific set-up) are considered as inevitably negative side effects of the imperfect character of actual scientific practice, such as lack of time, money or practical limitations (Goeminne 2013). Also, scientific uncertainty is presented as something that *depends on* decision stakes; i.e. risk managers have to decide upon scientific uncertainty because there is a preconceived one-on-one relationship between the world of 'science' and the world of 'politics' (EU 2000; Pellizzoni 2010). A good example to illustrate this is given in Regulation (EC) No 1829/2003, stating that the scientific evaluation performed by EFSA should be *followed* by a risk-management decision (Recital 9, own emphasis in italics).

In a wicked problem, scientific experts have no greater (i.e. objectifying) role in defining or structuring 'the problem' than non-experts. There is no greater legitimacy for their arguments in the problem-structuring process. This means that, instead of having to scientifically reframe ideologically-based arguments to obtain political effects, as in a moderately structured problem (means), it is more important to reflect upon which role is stipulated for science within a particular problem statement, and to incorporate the social and political dimension of scientific 'facts', as *matters of fact* are understood as *matters of concern.*

In this paradigm-driven view on scientific knowledge, scientific facts are no longer ideal representations, or mirrors of the world, but actively framed presentations of the world. This necessarily implies a politically significant differentiation between internalities and externalities. Scientific facts embody explicit models or assumptions about the society and the social world, and they embody specific concerns and interests which relate to particular paradigms to which scientists adhere (Pellizzoni 2010; Goeminne 2011, 2013) (see the glossary on paradigm-driven view on scientific knowledge). A dispute over the truth of a scientific answer is therefore broadened to also become a discussion about the way science frames its issues. Scientific

uncertainty, then, also *expresses* decision stakes, rather than simply being dependent on decisions. Consequently, the objectivity of science is not considered to be universal, but is achieved on the basis of what is excluded and how the issue is framed. Thereby, science still generates reproducible and verifiable forms of knowledge, but only in relation to a particular framing of the scientific (research) question.

In problem structuring, the scientific question matters too

This paradigm-driven, political view on scientific knowledge differs from the practices in a moderately structured problem (means) where science is quite narrowly discussed in terms of the *logical truth*, which is the truth of the scientific answers given ('who is right'), towards a scope where science is discussed in terms of the truth of the scientific question being asked, the so-called *topical truth* ('what is the matter of concern') (Goeminne 2011).

To briefly elaborate, the "topical truth points to the idea that behind the logical truth of any scientific answer, there lies a different kind of truth, the truth of the scientific question […] in other words, scientific facts are always already answers to a particular question, the latter expressing a particular view of being concerned with the world" (Goeminne 2013 pg. 97- 98). Examples of logical questions include: what deduction rules were applied?; while topical questions include: what is taken into account (internalities) and what is not (externalities) in the scientific set-up, or how are the internalities represented?; which (types of) methodologies are favoured, and why?; which policy goals can be (in)directly supported with this (type of) research? etc. (see the glossary on logical and topical truth).

So, instead of everyone claiming a particular objectivity (for its logical truth), it is more important to define and clarify the assumptions and exclusions that were made by actors to generate scientific facts e.g. about the safety of GM crops. This can broaden the scope of conflict, from matters of fact, to matters of concern, which allows a discussion beyond epistemological (Yes/No) questions about this technology.

A paradigm-driven view on science therefore holds important implications for the role of science within a socio-political problem framing, because "if it is impossible to know the world without acting upon it, if knowledge always has a negotiated quality, intimately connected with the social order, then there are no actors with exclusive or even privileged access to the facts". Rather, "choices must be grounded on social agreement, which in today's society means they must be democratically debated" (Pellizzoni 2010 pg. 471). This means that during the process of problem structuring it is important that the topical truths are part of the discussion, instead of the logical truths - namely focusing on the issue at stake. In so doing, the social and political dimension of

scientific 'facts' is better recognised as sidestepping the expert-laypeople divide. Once the problem structuring is 'completed' and has produced some new insights and new solutions *then* experts' scientific questions can be restructured alongside these outcomes to generate logical truths (for example, in relation to safety, long-term effects etc.).

This allows us to formulate a fifth condition for successful problem structuring in relation to a wicked problem, besides the four conditions already mentioned in Section 7.1.3. Being that the interrelationship between scientists and other stakeholders in this process of problem structuring first requires a focus on topical truths rather than logical truths (as a way to change the traditional hierarchies of knowledge). Namely, "joint fact-finding in a situation in which the policy problem is already fixed [e.g. in a strict science-based risk-regulation on GM crops] cannot prevent disagreement about the arguments that will be used to defend the policy proposal […] a new way of knowledge production rather requires a new way of policy-making. Governance strategies have to start with an open problem definition [that is to say, with a problem structuring]" (van Buuren and Edelenbos 2004 pg. 298).

7.1.5 A new role for gatekeepers

In relation to the process of problem structuring, our findings indicate that the business-as-usual attitude of gatekeepers towards supply-chain governance, private governance, periodic analysis and anticipation (Chapters 3 and 4), prohibit true participation in multi-stakeholder processes.

At most, a gatekeeper periodically analyses how the EU business environment for GM crop applications is evolving. Genetically modified ingredients were an option, at most, but not a pre-set end goal. This is quite understandable, as these food companies are primarily merchants of agricultural products, so they are able to adapt quite quickly when demand (clearly) changes (Camillus 2008). Our findings thus confirm that consumers play a crucial role in structuring the production chain with regard to GMIs, but also that companies mainly refer to 'imaginary' consumers (Van den Burg 2006), as they do not follow up the perceptions of their clientele towards GMIs in much detail. Therefore, when entering the process of problem structuring, gatekeepers will best enter from the perspective of their own topical truth (i.e. what the issue is for them, what questions and concerns these actors have on the issue), and not based on a kind of logical truth by arguing from an (imaginary) consumer perspective.

7.2 Which regime elements reproduce the systemic lock-in for GM crop applications within EU agriculture?

This section characterises the lock-in for GM crops within EU agriculture (RQ1) based on our analyses in Chapters 2 to 6. We will discuss these elements along the five 'subregimes' of the sociotechnical EU agricultural regime. These are the policy regime, the science regime, the technological regime, the socio-cultural regime, and the market regime. These elements will be presented in a narrative (story-like) way.

The systemic characterisation of the sociotechnical lock-in is a first step towards introducing a more systemic problem statement on GM crop applications - one that is less actor-dependent, but instead focuses on the taken-for-granted practices in agriculture, and how these co-determine the embedding of this technology within (new) sociotechnical practices. This involves analysing the lock-in for this technology as a means to understand how we have organised, or want to organise, modern EU society, and specifically EU agriculture. As such, we introduce a positive or opportunistic view on wicked problems, in that wicked problems can help us to reflect upon 'our' societal identity (Inghelbrecht et al. 2014b; Vandenbroeck 2012).

7.2.1 Matters of fact in the policy regime

Under the policy regime, important regime elements that socially reproduce the lock-in for GM crops within EU agriculture are:

- Evidence-based, risk-related, decision-making (facts as 'matters of fact')
- Role for government as the final decision-maker ('to give answers').
- A promethean discourse on technology.
- Focus on the possible negative consequences of introducing a new technology.
- Focus on the acceptability of new technology, resulting in Yes/No framings.
- Paying no attention to technological mediation effects.
- Transferring ethical concerns to the individual private sphere.

Our modern societies are structured along a divide between science and politics. Scientific facts are thereby generally considered as matters of fact, and not as matters of concern (François 2011). This endorses a one-to-one relationship between the world of 'science' and the world of 'politics', where scientific uncertainty depends on decision stakes rather than expressing choices (Section 7.1; Goeminne 2013, Jensen et al. 2003).

These perceptions and practices (regime elements) fit with policy makers' overall attempts to frame socio-political problems in the most structured way possible, using technocratic management or scientific expertise as *a*political devices within political problem statements (Hristova 2013; Maeseele et al. 2013; see also Section 7.1). Furthermore, stipulating facts as matters of fact fits with an overall role perception for government as being the final decision-maker: 'to give answers' rather than 'ask questions' (In 't Veld 2010), because acknowledging an inherent political dimension in scientific facts otherwise necessitates open, political deliberation about scientific premises.

Also, an overall Promethean discourse is institutionalised within modern EU society, whereby technology and innovation are considered as essential for economic growth (Dryzek 2010; Skogstad 2011). Discussions as to the acceptability of new technologies occurs mainly within a Yes/No framing, with a focus on the questions whether, to what extent and how individuals should be granted access to the new technology. However, these questions do not focus on how new technologies shape and participate in our way of life, or on the fact that technology and humans mutually constitute each other (Van Den Eede et al. 2015; Verbeek 2011). New technology is therefore assessed and approved with scant attention to the user context (which appropriates and accommodates the technology) and the focus lies on the possible negative consequences of introducing a new technology; not on the missed opportunities in the case of rejection (Jensen 2006; Tait and Barker 2011).
This all co-creates today's regime where ethical arguments about the products of modernisation, science and technology (such as GM crops) may prevail in individuals' private spheres, but not in society's public sphere (Goorden 2004; Verbeek 2008a). This means that offering freedom of choice by offering a set of options can be considered as a kind of trade-off set by policy to proceed with technological innovation in general.

An important step forward to address the lock-in for GM crop applications within EU agriculture, therefore, requires us to extend the focus beyond matters of fact and individual freedom of choice in the political problem statement (see also Sections 2.2 and 7.1). It is also important to pay attention to technological mediation when approving new technologies, because the current absolutist and functional view on technology in the policy regime is rather counterproductive. It treats technology as an invasive power that exerts its effects upon society ('society *vs* technology), whereas policy can better focus on what kind of moral subjects the technology generates and how the technology shapes, and can improve, the quality of our lives (see also the discussion of the technology regime) (Goorden 2004; Verbeek 2008a, 2011).

7.2.2 Objectivity in the science regime

In the science regime, important regime elements that were identified in relation to the socially reproduced nature of the lock-in under study are:

- A representational view of scientific facts (science as 'matters of fact').
- Science giving the right answers.
- Science as an objectifying discipline (a universal objectivity is claimed).
- Science is legitimate in itself.
- Stipulating scientific facts as 'politically neutral'.
- Institutionalisation of a science-industry complex.
- Science with an applied research focus.

'Traditional' knowledge production within EU agriculture builds on the belief that it is possible to generate certain, universalistic knowledge (Loeber 2007 pg. 407); that there is only one reality to represent. This representational view on scientific facts treats facts as being matters of fact, as facts 'per se'. The externalities in scientific practices (things that have not been taken into account) are formulated as negative side-effects of the imperfect, and human, character of actual scientific practice (Goeminne 2013).

Dominant practices within the science regime also present science as an objectifying discipline, with a clear distinction between the world of 'science' and the world of 'politics' (Jensen 2006). The objectivity of science is thereby claimed to be universal, rather than being achieved on the basis of what it is excluded and how the issue is framed (Goeminne 2011). This reinforces an idea of scientific 'politically neutral' facts within the dominant regime practices in EU society today, with the resulting discursive battle about the value of specific scientific 'facts' and a situation in which contesting parties gather their own body of relevant facts by searching for so-called knowledge coalitions with their own rules and roles in the game that lead to objective results against a particular background of exclusion (Goeminne 2011, 2013). Also, the "scientific discourse seems legitimate 'by itself' and apparently is in no need of further justification" (François 2011 pg. 167). It is actually both a societal expectation and a norm for science to provide the 'right' (and objective) answers (Pellizzoni 2010). This is within an overall context of today's science-industry complex, where the privatisation of science leads to an overall practice of science as a private, instead of a public good, with an applied research focus (Vanloqueren and Baret 2009).

As a possible way forward with the lock-in, the political contract for science needs to be revised. For this, it is important to accept different role expectations for science in relation to different problems. Science cannot structure every problem in the same way, and it is important to show which role is stipulated for science within a particular EU problem statement (Hisschemöller and Hoppe 1995; Wesselink and Hoppe 2011). There is also a need for clearer political deliberation on scientific uncertainty and there is a need to politically acknowledge the social and political nature of scientific 'facts'. This implies a transition in scope from matters of fact to matters of concern (François 2011). These proposed changes in the science-policy interface are the responsibility of both the scientific and political communities. It is a responsibility of the political community, because if policy makers include the logical truth within the problem definition (as in practices of depoliticisation) then they automatically assign science a highly structuring role. Perhaps, public participation should be included within the risk assessment used for policy making, as a way to include the divergent interpretations of scientific shortcomings held by different actors (Devos et al. 2014). Changing the science-policy interface is also a responsibility of the scientific community, as risk-assessment studies should specify the types of uncertainty encountered and their relative importance to the results of the risk assessment, in a transparent way (Myhr 2007). Scientists should be more open about the topical truths behind the truth of any scientific answer. Objectivity can only exist against what is excluded; there is no ultimate foundation upon which to calibrate it.

7.2.3 A functional, externalist view on technology in the technological regime

In the technological regime, important regime elements that socially reproduce the lock-in for GM crops are:

- Technology is seen as functional.
- Strong externalist view on technology.
- No attention given to the mediating capacities of technology in its design or authorisation.
- Freedom of choice as a trade-off to continue with technological progress.

This lock-in is reproduced by a strong functional (either instrumental or deterministic) view on technology within EU society, in an overall macro-repertoire of technical progress, modernisation and industrialisation (Geels and Verhees 2011). Debate about a (new) technology focuses rather exclusively on safety issues and on defining a set of criteria in which the technology can be permitted (in relation to the policy regime; Verbeek 2011).

Together with an externalist view on technology that seems to be institutionalised within EU society, this leads to an absolutist stance on technology, where technologies is only discussed in the format of acceptance or rejection *tout court,* and this has led to the current Yes/No framings on new technology. Also, the motives and the supposed inflexibility of the technology developers are taken as a given in this externalist and absolutist view on technology. In doing so, technology (in our case GM crops) obtains agency within today's agricultural crop production system.
There is also a general lack of attention on the mediating capacities of technology in today's technology regime (Van Den Eede et al. 2015). This means that no consideration is given to how technology applications help to shape human interpretation and human action (Verbeek 2008b, 2011). The discussion also gives scant coverage of how individuals can be empowered in relation to technological mediation.

Verbeek (2011) nicely formulates a potential way forward here, namely "now that we have seen that technologies always are involved in shaping human actions and decisions, paying deliberate attention to the mediating role of technologies in fact comes down to accepting the responsibility that technological mediation implies […] [so] we better try to give this influence a desirable and morally justifiable form […] arrangements should be developed, therefore, to democratise technology development" (pg. 96). To do so, it will be important to combine the context of design with the context of use when developing new technology applications; and it will be important to challenge the prevailing functional, externalist and absolutist view on technology within EU practice.

7.2.4 Influence of mediation in the socio-cultural regime

Within the socio-cultural regime, the following regime elements socially reproduce the lock-in for GM crops within EU agriculture:

- Democratising policy by means of public participation.
- Public participation with respect to new technology is largely limited to individual consumer choice.
- EU labelling standards do not empower individuals in relation to technological mediation.
- Freedom of choice is equated to giving a particular set of options.

The socially reproduced nature of the lock-in involves the overall interpretation of democratising policy by means of public participation in the decision-making process. Including non-state actors is considered a good way to limit state sovereignty and to make the political decision-making more

inclusive or democratic (Goeminne 2013; Gottweis 2008; van Buuren and Edelenbos 2004). However, the translation of public participation should be understood more as individual consumer involvement, as it is a general premise that as long as technological products are considered to be safe, no particular attitude for-or-against the technology should be favoured by the law (Jensen 2006).

However, the current EU GM labelling standard does not visualise differences between GM crops or different sociotechnical practices with a GM crop. This absence of differentiation in labelling is actually not exclusive to the GM label. For example, the standardised EU organic label also does not differentiate between e.g., a transcontinental imported organic product *vs* a product that is produced via a short-supply-chain, although both imply a different morality due to more, or less, similarity with the agro-industrial model. This means that the current ways of labelling do not really empower individuals in relation to technological mediation. Freedom of choice is only interpreted in terms of offering someone a particular set of options. 'Having freedom' is thereby translated as 'having options', but this only involves a particular form of individual empowerment.

Instead of focusing on a *transfer of power* (e.g. through participatory democracy), an important way forward can be to focus on the *transformation of power*, which aims to produce a particular kind of human subject in relation to new technology (Blakeley 2010; van Buuren and Edelenbos 2004). Freedom of choice then no longer just implies having options to choose from, but refers instead to having an understanding of the moral subject that new technologies and power structures generate. It also means that the existing dualisms between *society vs the state* and *society vs technology* are both based on an externalist and socially disembedded view, where both the state and technology are supposed to exert 'their effects' upon society. But as Verbeek (2011) explains, this externalist view makes people objects that are subjected to all kinds of external influences, while these influences are the precise background that gives individuals identity and subjectivity. That is "the [human] subject is not what is left when it is stripped from all power and mediation, the subject is just the result of active engagement and channeling the effects of these powers and mediation" (pg. 106). Under this view, we need to think about how to enable individuals to 'read' forms of technological mediation so that they can develop their own identity in relation to it. Perhaps this can occur by giving more information than the current forms of labelling, or by establishing a closer link between the context of design and the context of use in order to better estimate the (Human) - Technology - (World) relationship that new technologies mediate.

7.2.5 In the market regime: overlap between agriculture and the food industry

In the market regime, important regime elements that socially reproduce the lock-in for GM crops within EU agriculture are:

- Scale economy.
- Decoupled food production and food consumption.
- Institutionalised overlap between agriculture and the food industry.
- Vertical power hierarchy and segmentation in the supply chain.
- Appropriationism in agricultural production.
- Depersonalised services, leading to commodity consumerism.
- Commodity agriculture, with product standardisation, bulk production and uniformity of agricultural products.
- Levels of output as a measure of efficiency.
- Vegetable protein supplies organised as a globalised agricultural practice.
- Symbolic value of intensive livestock farming, including soya as a resource.
- Embedded neoliberalism in globalised resource flows.
- Farm-to-fork traceability as a means to control globalised agricultural practices.
- Agriculture as agribusiness.
- Executive role for the farmer in both crop production and crop innovation.

Elements in the market regime that socially reproduce the lock-in for GM crops involve practices with respect to scale economy (with increased forms of concentration) and a decoupling between food production and consumption which have resulted in an institutionalised overlap between agriculture and the food industry. In this overlap, the social role of agriculture is predominantly mono-functional, as agriculture is seen as the producer of industrial inputs for the (food) industry (Pechlaner 2010, 2012). This further normalises a vertical power hierarchy and segmentation in the supply chain, which both contribute to socially reproducing the lock-in. Other regime elements that explain the lock-in are standardised practices of appropriationism, where natural production processes are increasingly replaced by industrial activities in crop production (e.g. the use of pesticides). Also practices of commodity consumerism and commodity agriculture are normalised within EU practice, both of which include product standardisation, bulk production and uniformity as far as possible. In these practices, 'levels of output' are a standardised measure of efficiency (a focus on productivity).

In the market regime, the importance of intensive livestock farming also plays a role in reproducing the lock-in for GM crops, because vegetable protein imports are standardised in EU agriculture, together with the high symbolic value given to soya (derivatives) in compound feed production. In these global resource flows, a farm-to-fork traceability is normalised as a means to obtain consumer trust and to apply the polluter pays principle. These globalised resource flows are even formalised in WTO agreements, albeit in an overall EU context of embedded neoliberalism where a focus on export markets is combined with own market protection (Potter and Tilzey 2005). Agriculture is also increasingly considered as agribusiness, with private capital investments and specialised R&D centres that deliver agricultural innovations in a knowledge-based agriculture. This increasingly results in an executive role for the farmer in both crop production and crop innovation, which contributes to the reproduction of the lock-in.

As a way forward, it will be important to bring these elements directly into the discussion, instead of discussing GM crops in order to stimulate this societal debate (Section 7.3).

7.2.6 Characterising the lock-in beyond the problem statement of actors

Based on the above characterisation of the sociotechnical lock-in, we can differentiate between regime elements that are explicitly present in actors' problem statements on GM crops, and several regime elements that are not.

Many of the regime elements under the market regime, for example, were directly present within the discourses discussed in Chapter 3. These regime elements are thus explicitly part of the ongoing discussion. However, this characterisation of the lock-in also points to several regime elements that are not (or not yet) part of actors' problem statements on GM crops. Apparently, these regime elements are still self-evident or considered unimportant. Illustrations are, for example, that freedom of choice is equated to giving a particular set of options; that freedom of choice is taken as a trade-off to continue with technological progress; or that an externalist view on technology prevails. These regime elements also reproduce the lock-in for GM crops, but they have not been part of the debate, so far.

This demonstrates the relevance of our analysis, for two reasons. First, this characterisation of the sociotechnical lock-in introduces a more systemic problem statement on 'the problem'. This is, a problem statement that also includes the taken-for-granted practices within the EU agricultural regime. Secondly, this analysis shows that technology and technology development when viewed

from this sociotechnical angle, delivers a societal reflection upon the norms and values within society. So, overall, this analysis can provide an opportunity to change the current 'battle for the best framing' of the problem with GM crops, towards a public consideration (perhaps reconsideration) of what 'our' societal norms and priorities are or should be.

7.3 Understanding the polarisation around an incremental innovation

In this section, we summarise how we dealt with the second objective of this PhD dissertation, namely to understand why the ongoing EU debate about GM crops evolves along a dichotomous Yes/No framing, and why this incremental innovation is so highly contested (RQ2).

Based on the analyses in Chapters 2 to 6, we can conclude that the overall tone of the GM debate in the EU is *defensive* (Goorden 2004) and this is for at least two reasons. The first reason is the strong prioritisation of scientific facts within the EU policy process, because of the risk-based regulation and practices of depoliticisation. This automatically creates a setting of having to justify one's stances and having to reframe arguments in a scientifically found way to achieve political impact. Secondly, the strong externalist view on this technology also results in a defensive tone, as GM crops are supposed to exert their effects upon society and are hereby given agency. This contributes to the 'take it or leave it' discussion on this technology, within a Yes/No framing.

Why this incremental innovation is so highly contested

The discourse and content analyses in Chapters 3 and 4 explain the strong opposition to GM crops from (1) different agricultural outlook perspectives (different ideals on agricultural production) and different value assessments of GM crop applications. (2) The contestation also results from different economic interpretations to uphold a particular business strategy (specific for an agribusiness actor), and (3) from some actors' particular by-default perceptions, which perceive or experience GM crops as being imposed on EU agriculture or agribusiness due to the characteristics of agricultural markets. (4) Contestation also results from imitation behaviour, either faddish or fashion imitation; (5) inconsistencies in the political dimension; or (6) the fact that behaviour towards GM crops is often institutionalised, which causes new entrants to adopt the same behaviour without any further reconsideration.

Both chapters can explain the strong contestation about GM crop applications (from an agribusiness perspective), but they were less oriented in terms of why this particular incremental

innovation is contested, and why in a Yes/No framing. These questions were answered mainly based on the analytical narrative in Chapter 5 and the technological mediation analysis in Chapter 6.

The narrative in Chapter 5 explains the strong opposition to GM crop applications within the EU (1) as a coincidence of circumstances such as the BSE crisis and political opportunity structures. (2) This particular technology was also used as a symbol for a globalised and external-input dependent EU agriculture and could thereby increase the visibility and proximity of regime problems that regime outsiders put forward. (3) There was also a lack of empowering and nurturing strategies when appropriating the technology in a use context during the first R&D period. (4) The disruptive conduct of this innovation also had an impact, as introducing expropriationism and, accordingly, the proletarianisation of the farmer may have been just a step too far along the already ongoing private funding of agricultural innovation.

The mediation analysis in Chapter 6 explains the strong opposition to GM crop applications based on (5) their current mono-stability and mono-identity, pointing to a lack of attention to the human-technology association when defining and interpreting technology. (6) There are also strongly incompatible discourses present about technology *per se* amongst social actors, including both technological instrumentalist and technological determinist views. (7) The externalist and absolutist view on this technology also creates a setting where the technology can only be accepted or rejected tout court. This Yes/No discussion makes 'winning' the only acceptable outcome. (8) The fact that political practices only enable social actors to relate to this technology in an 'A + B' format (in short: safety + freedom of choice, with the GM label only supporting a 'take it or leave it' attitude), can also explain the strong Yes/No contestation; and (9) the particular amplifications/reductions and invitations/inhibitions of GM crops within their current mono-stability has established intended or unintended technological mediation effects that could unfreeze moral routines, or directly introduce hot ethics.

Both Chapters 5 and 6 have also shown how GM crop applications could stimulate the debate about institutionalised practices from different angles, resulting in specific discussion about this incremental innovation. Namely, Chapter 5 explained how the confirmative conduct of GM crops was used by regime outsiders in discursive battle. Chapter 6 demonstrated how GM crop applications could stimulate the debate about institutionalised norms, values and practices by means of confirmative mediation. Both these chapters, therefore, make reference to the fact that emerging innovations and their accompanying promises and concerns, can rob moral routines of their self-evident invisibility and turn them into topics for discussion, modification and

reassertion – making 'cold' morality 'hot' ethics again in the wording of Swierstra and Rip (2007). GM technology also stimulated the debate because it simply changed the normality of the way things were before, as new technologies generate new options of choice and new opportunities for control (Verbeek 2011). GM crops could, for example, change the norm on control (ability) in agricultural production, which, in a way, makes farmers more responsible for failed or reduced harvests.

Ethical concerns have co-evolved with the development of GM crops

Ethical concerns regarding agricultural practices have therefore evolved alongside the material development of GM crops (Driessen and Heutinck 2012), in the sense that new technologies can either defrost cold morality or directly introduce new forms of hot ethics through their disruptive conduct and mediation. These conclusions put forward that, in addition to the historical context and the disruptive conduct of this innovation, parts of the EU discussion about GM crop applications can be understood by the fact that it is a technology-in-use with particular amplifications and reductions, invitations and inhibitions, which lead to intended and unintended, confirmative and disruptive conducts and mediations. Together this can explain why this particular incremental innovation has led to such an extensive amount of debate and why GM crop applications could not directly benefit from their structural fit with prevailing regime practices. An overview of these findings is given in Figure 7.1.

The figure shows that the EU discussion on GM crops results from the confirmative conduct and incremental nature of these applications; from their disruptive conduct; and that yet another part results from what we have called circumstantial and institutional factors (referring for example to a co-evolution with societal developments or to the presence of an externalist and absolutist view on this technology within EU society). The figure also shows that confirmative conduct can either be the result of a spontaneous contextualisation of the technology within already existing devices and systems, as these systems have various social characteristics such as standard user preferences, ethical and aesthetic principles, or industrial production standards (Geels 2004, 2011); or as an explicit choice for an incremental design in order to increase the likelihood of being used (Chapter 5). Disruptive conduct can either result from interpretations that the moral change is almost inevitable; or thought to be in line with the established norms or dominant practices (Swierstra and Rip 2007).

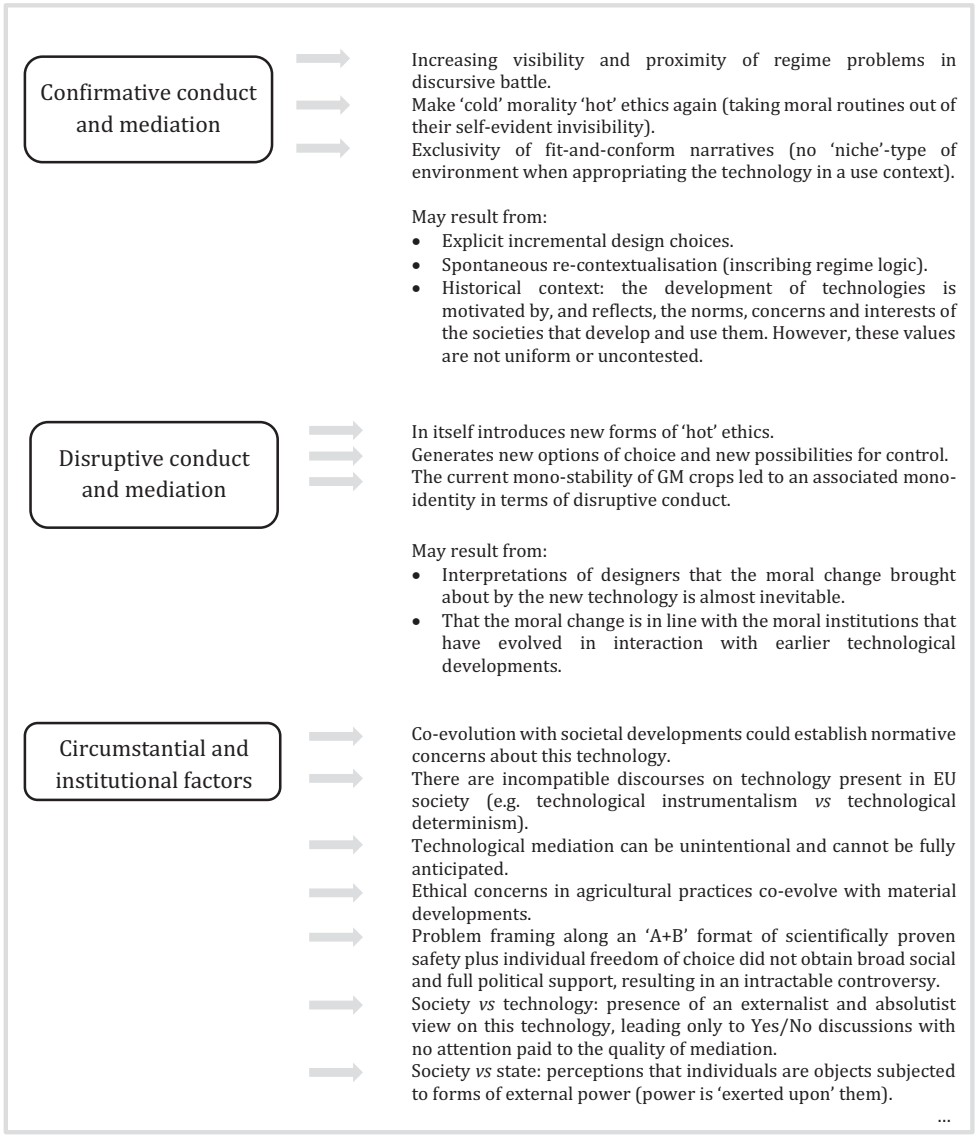


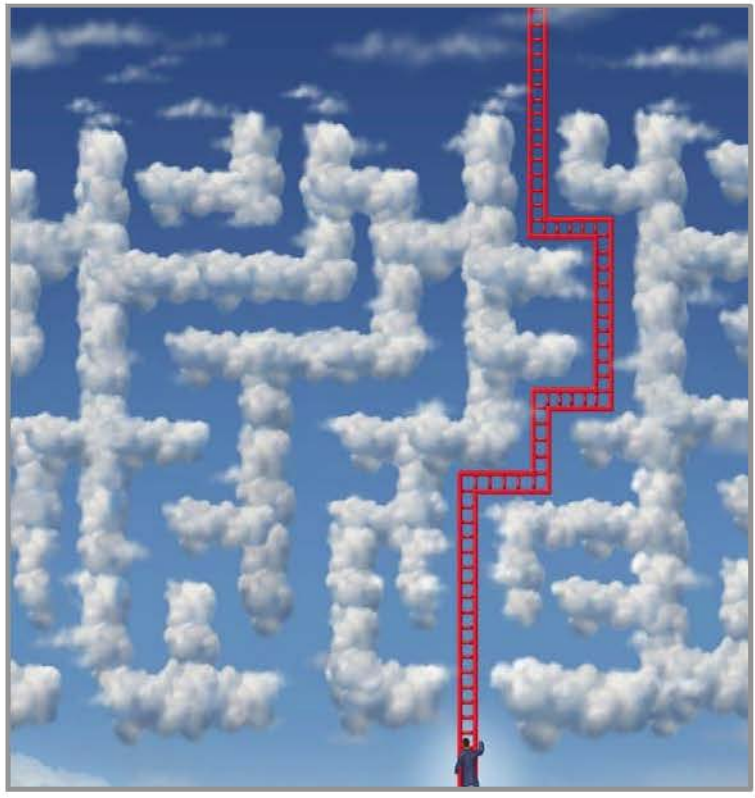
Figure 7.1. A summary of the research findings on the second objective. This figure overviews our findings of why GM crop applications could not directly benefit from their structural fit with prevailing regime practices, and why this particular incremental innovation has led to such an extensive amount of debate.

7.4 Conclusion

In sum, this chapter demonstrates the important contribution of GM crops in challenging the basic social, political and cultural principles of our 21st century EU society. For instance, do we support

or oppose globalised agriculture? Do we accept a vertical power distribution in our food supply chain? Do we accept public-private partnerships in fundamental research funding? These dilemmas and tensions are valuable, as they help organisations and communities to reaffirm their roots and express their desires about the future (Inghelbrecht et al. 2014b). Therefore, regardless of whether or not GM crop applications are implemented on a larger scale within EU agriculture, they have generated discussions that matter within the EU.

CHAPTER 8.
CONCLUSION AND FUTURE OUTLOOK



Creativity is intelligence having fun (Albert Einstein).

CHAPTER 8.
CONCLUSION AND FUTURE OUTLOOK

"It's better to know some of the questions, than all of the answers." (James Thurber)

8.1 Contours of the thesis

The dissertation takes a social constructivist approach. It aims to characterise the ongoing EU debate about GM crops beyond a dichotomous Yes/No framing, and to understand why this particular incremental innovation has such a hard time breaking through. We approached this by accounting for different actors' interpretations of 'the problem' in Chapters 3 and 4; by including the historical co-evolution of technological and societal developments in Chapter 5; and by anticipating the potential technological mediation of GM crops within their current mono-stability in Chapter 6. Actors, structures and the technology itself were therefore all considered to be an integral part of both the problem statement and the problem solution (see also Chapter 2 and Figure 2.2).

We used the concept of wicked problems to introduce this systemic characterisation of the lock-in. As such, we included in the analysis elements of the existing structures within EU agriculture that are not necessarily part of actors' problem statements (Schuitmaker 2012) (Section 7.2). Wicked problems also centralise the relationship between science and policy. This led us to reflect on the socio-political structure of the problem with GM crops in EU society, showing that (the implementation of) the risk-regulation presents a moderately structured problem (means) which has not achieved full societal or political support (Section 7.1). Therefore, this concept was a very interesting perspective from which to analyse the case study.

Of course, such a systemic characterisation of the lock-in cannot directly provide firm levers for managing the problem (as viewing the problem at a systemic level, will point to systemic solutions). It only identifies a number of norms, practices and role expectations that reproduce the lock-in, such as an externalist, absolutist view on technology, or today's restrictive interpretation of freedom of choice as a trade-off for continuing with technological innovation. These are all extremely difficult, but highly valuable, societal dilemmas that can become the starting point for moderating the system change needed to address this wicked problem. This work thus stimulates reflection on institutionalised practices and rationales within modern EU agriculture, and takes technologies, and especially their controversies, as a means to understand

how modern EU agriculture is organised. Therefore, the work is certainly normative, albeit in a non-moralistic way: it points towards new levers for normative change, but it does not say which direction such change should take. Multi-actor processes are key in this regard. Prescriptive questions on how to address the lock-in should therefore evolve into a reflection about what GM technology can teach us about society, technology design and technology development. Therefore, it is important to pose different questions about technology, paying attention to technological mediation effects, and the confirmative and disruptive conduct within the sociotechnical practices that embed technology, etc. This makes the overall intention of this PhD *reflective* and not prescriptive in how to move forward with this sociotechnical lock-in.

In the remainder of this chapter, we will generalise our case-study findings to improve future technology design so as to fulfill broader societal goals (Section 8.2). We will formulate several policy recommendations in Section 8.3, and promising avenues for future research in Section 8.4. Finally, we summarise our main findings in a number of key take-home messages in Section 8.5.

8.2 A new perspective on technology and its design

This PhD recommends improvements in the design of future technology so as to fulfil broader societal goals, by revealing (i.e. making explicit) basic norms and values that have become self-evident either within the technology itself, or in its anticipated forms of use.

We have shown that technological intentionality should not be overlooked, because technologies are directing, as they afford specific opportunities for action or disclose 'the world' in a particular way. However, technologies only gain meaning within a user context, as the context interprets and appropriates the affordances of the technology in line with its own perceptions and programs for action. Technological mediation therefore emerges from the human-technology associations (Chapter 6). This brings us to the question of *how* to design for technological mediation and, unfortunately, mediation theory is not yet strong as a methodology for this. As Verbeek (2006b, 2011) explains, it will be important to pay special attention to:

(1) the script and user logic;

(2) the intended mediations (deliberately inscribed into the technology);

(3) the kind of mediated subject that results from these intended mediations;

(4) the implicit mediations evoked by the design, as far as they can be anticipated;

(5) the forms of mediation involved;

(6) the outcomes of the mediation;

(7) the potential to empower human beings, by co-designing the impact of these mediations in terms of their subjectivity;

(8) to perform a moral assessment of (the quality of) the intended mediating effects;

(9) to anticipate mediation along a structure of amplification and reduction, and invitation and inhibition.

Our results can add, that in the design of new technology it is further important:

(10) to apply the 'IS', 'CAN' and 'OUGHT' subdivision when estimating potential forms of technological mediation (based on our adjusted matrix in Chapter 6);

(11) to include a systemic view in the design and anticipation of the AB hybrid in technological mediation analyses, as both the materialising values and the human intentionality should be analysed within an overall context of systemic structuration;

(12) to explicitly anticipate confirmative mediation;

(13) to structure the anticipated mediations in relation to the prevailing system structure (determining confirmative or disruptive mediation).

In future technology design, the systemic relationship between the new technology and the dominant regime practices within a sociotechnical system (such as EU agriculture) also need to be anticipated. This involves specifying the confirmative as well as the disruptive conduct of a technology-in-design. This was one of our reasons for arguing that a niche-type environment should also be established for incremental innovation designs, because in designing new technology the focus too often lies on the new practical affordances of the innovation (i.e. the disruptive conduct), while the established regime practices are too easily taken for granted.

Establishing these niches involves multi-actor processes in which the first important step will be to structure 'the problem' that the new technology will address. This will require the establishment of heterogeneous/dispersed networks in order to capture ideas from outsiders and to focus on second-order learning as to reflect upon the incremental elements (Chapter 5). Within such a niche space, the hybrid actor AB can be more carefully designed and anticipated in an iterative and multi-actor process; rather than in a sequence where a new technology is developed for a potential user context and then observations are made about how the technology-in-design

relates to dominant regime practices. In a mere sequential 'A + B' format such as this, one can only really anticipate how new technologies emerge in their design context, while the user context remains largely black-boxed. It is therefore important in the design of new technologies to define the elements of both confirmative and disruptive conduct because:

(1) this anticipation is a proactive way to introduce a systems' perspective into the design of new technology;

(2) it allows reflection about incremental elements in the practice-in-design;

(3) it is a way to automatically approach the influence of a sociotechnical regime in terms of being both enabling and disabling (a double focus).

Of course, designers do not develop new technologies blindly, and the selection environment for the new technology will also be anticipated so as to avoid putting a lot of effort into developing technologies that will not be accepted by consumers or the government (Verbeek 2011). However, it is important to put the anticipation of both confirmative and disruptive conduct and the estimation of confirmative and disruptive forms of mediation explicitly on the agenda in these niche practices; otherwise these are likely to remain hidden or transparent.

Applying these concepts as a *heuristic* (guiding the analyst's attention to relevant questions and patterns) in future technology design is interesting for several reasons. The first reason is because using the concepts of confirmative/disruptive conduct and mediation automatically poses the question '*how* should we think differently about technology in a design practice?', rather than 'should we think differently about technology?'. Secondly, the anticipated conduct and mediations of the actors involved in the design practice (and their classification as disruptive or confirmative), is a good way to get to know the frames of reference for the actors involved in the design practice. This can be used to stimulate intense debate within the design practice.

Of course, applying these concepts as heuristics raises questions, such as how to use (and introduce) these concepts within the design practice in a way that is not predetermined, and how can the answers be more than individual representations? This provides an interesting perspective for future research (Section 8.4).

8.3 Policy recommendations

A number of interesting insights and policy recommendations result from this work, as to address the current deadlock. Yet, it is the responsibility of policy makers to translate these insights at the appropriate policy levels.

(1) Engage in a proper problem structuring

We have explained that the socio-political framing of 'the problem' with GM crops as a moderately structured problem (means) has not gained societal or full political legitimacy. It simply leads to the existence of knowledge-coalitions with different cultures of concern which generate their own body of scientific facts ('logical truths') to obtain a political hearing for their stances. Also, the current participatory arrangements cannot work well in combination with the evidence-based risk-regulation for GM crops. Field trials, field trial demonstrations, courtrooms, supermarkets, … these are now all *politicised spaces*, not necessarily designed for, but they put up new forms of participatory governance which challenge the current socio-political problem framing for GM crops. Therefore, it will be important for EU policy to focus on problem structuring. It is key to this approach that policy makers create a trust environment where a heterogeneous group of actors with multiple views and frames on the problem are brought together. This problem structuring is about creating trust and cultural legitimacy for a (new) problem definition. It involves articulating roles, generating trust and deliberating on problem definitions and solutions. Spaces like these are needed, because there can be no simple or straightforward top-down solutions to this conflict. This process of problem structuring does not discard the role of policy making and the scientific role of determining future risks in relation to GM crops. What is different, are the different roles and mutual relations of science, policy and society at large, in defining 'what is the problem'.

(2) Empowerment of citizens in relation to technological mediation

Citizenship in a technological culture such as modern EU society requires the ability to understand how technologies shape society. Attention should therefore be given to the ways in which technology helps to constitute human subjects, the world they experience, and the way people live their lives. It involves asking 'what moral questions' are posed by the new technology (practice), and 'what ethical answers' are suggested. The issue, then, is no longer whether to accept GM crops, but whether to accept the forms of technological mediation involved. For policy, it is therefore necessary to think about new ways to inform individuals about technology and its mediated values, norms and the practices involved. This is particularly the case here, because this work has shown how the current GM labelling standard only reinforces a 'take it or leave it' attitude on GM crops which does not permit a discussion beyond a Yes/No framing (Chapter 6). In so doing, modern EU society would enable more systemic discussion and offer more room for *public reflection* than for *public opposition* to GM crops. This is exactly what we gain by the mediation approach: these dilemmas and tensions are valuable in themselves as they help individuals and organisations to reaffirm their roots and express their desires about the future.

(3) Stimulate design of sociotechnical practices around GM crops

The current ad-hoc combination of script and user logic when designing and authorising a GM crop in the EU cannot anticipate technological mediation effects very effectively. We therefore suggest a policy to stimulate the design of sociotechnical practices around GM crops, where the context of design is more closely interrelated with the context of use, with lots of feedback loops, to actually create an AB actor iteratively. This stimulation can occur in a rather top-down way, where the authorisation process includes, for example, particular criteria for estimating technological mediation effects. Perhaps this may extend the current process-based regulation towards a more *practice-based* GM crop legislation. Stimulating the design of these sociotechnical practices can also occur with less regulatory interference, for example, by showing actors the relevance and benefits of such a reflexive design for sociotechnical practices around GM crops so they may be motivated to take up the initiative themselves.

8.4 Future research and outlook

A number of interesting future outlooks can be formulated based on our analyses.

(1) Starting-up a process of problem structuring

A first future outlook involves defining how to start the process of problem structuring, in relation to GM crops, and defining how such a process should proceed in practice. It will also be necessary here to think about how to make a switch in the political decision-making process, because there is a need for the political will to reconsider the EU political problem statement.

(2) Extending the typology on socio-political problems

Paying more explicit attention to both the logical and topical truths in the characterisation of socio-political problems may add an interesting dimension to the current typology of Hisschemöller and Hoppe (1995) by also recognising the social and political dimension of scientific 'facts'. Because the assigned role of science is currently based on how the worlds of science and politics are *interrelated* but not yet *reciprocal*. It is therefore an interesting research outlook to include the concept of topical truth into this framework.

(3) Heuristic devices to guide the design of new sociotechnical practices

Future research should involve defining how to use the concepts of confirmative and disruptive conduct, and confirmative and disruptive mediation, in a more *prescriptive* and practical way by

turning them into heuristic devices for the design process of new technology. So far, these concepts were only introduced, and applied, in a reflexive mode in this thesis to understand what processes were going on.

(4) Design for technological mediation

A final interesting future outlook of this work relates to the question of how to design for technological mediation and how to design GM crops with attention to technological mediation. As explained, anticipating the script and user logic in the design of new technology is important, but future research is needed on how to design the hybrid actor AB more carefully within an iterative and multi-actor process.

8.5 Short messages

As a concluding step in this PhD dissertation, we will summarise our main findings in a number of take-home messages:

(1) GM crops could revive, and reinforce, certain discourses that criticise institutionalised practices within EU agriculture. One of the reasons for this is that regime outsiders, such as special interest groups, have used GM crop applications to symbolise globalised and input-dependent EU agriculture. As a tangible symbol for this type of agriculture, GM crops could bring these perceived 'regime problems' closer to the daily life experience of as yet unconcerned actors, such as citizens or consumers. The high level of contestation about GM crops in the EU also partially results from the co-evolution of societal and technological developments, where political structures and alignments with market developments have consolidated particular normative concerns about this technology.

(2) Technologies are not neutral devices. Although technologies 'are what they are' because of the meaning that is conveyed on them through the ways in which they are used, they afford specific opportunities for action or they disclose the world in a particular way. A trait of herbicide-resistance, for example, 'demands' spraying; while a drought-resistant GM crop materialises ecological modernisation, as it offers a shortcut technical solution to cope with environmental problems without changing our production system.

(3) Both proponents and opponents hold the same absolutist view about technology, where it can only be accepted or rejected *tout court*. Both see technology, once designed, as decoupled from human intentions; either as an all-encompassing negative force that determines societal evolution (as in technological determinism) or as a neutral instrument

that can be employed at will (as in technological instrumentalism). This could explain why the ongoing debate about GM crops has been narrowed down to a social polarisation or a dichotomous Yes/No framing on whether or not to include GM crop applications within EU agricultural practices.

(4) The debate about GM crops is legitimate and relevant, as GM crops have turned several morals and routines in EU agriculture into topics for ethics again. For example, GM crops amplify a norm of control and controllability in agricultural production, where expecting a good harvest may increasingly become choosing a good harvest. GM crops also introduce 'hot' ethics, for example, by directly interfering with our definition of 'a biological species'. Currently, this definition is based on a strict pattern of intersecting lines, whereas with the possibility of transgenes it may become more of a political definition in the future.

(5) In the debate, however, the dichotomous Yes/No framing on whether to accept GM crops, focuses too much on the technology itself and too little on the system underneath. The debate therefore misses important parts of what this debate could, or should, be about: it is about how we have organised, or want to organise, modern EU agriculture. The questions should be about how GM crops shape and participate in our way of life; what norms, values and practices these applications normalise; or what disruptions they introduce. By doing this, modern EU society would offer more room for public reflection than for public opposition on this matter. An important attribute of GM crop applications is therefore their current ability to challenge the basic social, political and cultural principles of our 21st century EU society. These dilemmas and tensions are valuable, as they help organisations and communities to reaffirm their roots and express their desires about the future.

(6) The overall tone of the GM debate in the EU is defensive and this is for at least two reasons. The first reason is the prioritisation of scientific facts within the EU decision-making process because of the risk-based regulation and practices of depoliticisation (followed by a political impasse). Yet, this automatically creates a scenario where actors have to continually justify their stances and reframe arguments in a scientifically proven way to achieve political impact. Secondly, the strong externalist view of this technology also results in a defensive tone, as GM crops are supposed 'to exert their effects' upon society and are hereby given agency. This contributes to the 'take it or leave it' discussion on this technology, within a Yes/No framing.

(7) We explain that the current legislative formulation of the problem with GM crops along an 'A + B' format of scientifically proven safety *plus* individual freedom of choice – together with the way in which it has been brought into practice - stipulates the 'wrong' socio-political problem with GM crops. Namely, the formulation, and implementation, of the risk-

based EU legislation on GM crops puts forward a moderately structured problem (means), where the high levels of conflict about values and concerns amongst societal actors are mitigated by trying to reach a compromise on the means to enable a future consensus. This, however, leads to current practices of depoliticisation at the level of the European Commission, and a political impasse in the comitology amongst Member States' risk managers.

Some of its main difficulties are:

(a) the strong (factual) dissent about the environmental and health risks of GM crops. This is either because the actual level of agreement about the safety of GM crops is less than presumed, or because ideological arguments are (have to be) reframed scientifically to obtain a hearing in the political decision-making process.

(b) The confidence of EFSA in the scientifically proven safety of GM crops is based on a particular culture of non-knowledge (with particular methodological preferences and assumptions) which is currently not specified and therefore not open for discussion. This denies the social and political assumptions underlying EFSA's assessments of scientific data and gives no legitimacy to other cultures of non-knowledge.

(c) Public concerns and problem statements are not acknowledged in the general authorisation process. Public resistance is forced into a risk regime in which the only possible demand is the demand for greater safety.

We therefore conclude that EU policy currently addresses the 'wrong' socio-political problem with GM crops, resulting in today's intractable controversy where parties bombard each other with scientific facts, while the actual debate remains deadlocked.

(8) As a first, important step forward, there is a need to use the peripheral openness towards non-scientific argumentations within the general EU authorisation process for new GM crops, in order to take into account the existing diversity in argumentations. If not, logical truths will remain the focus of future discussion while the actual debate remains deadlocked.

As an alternative, it is important to focus again on problem structuring based on a strategy of 'policy as learning'. This involves a change, from framing the socio-political problem with GM crops as a depoliticised moderately structured problem (means), to framing it as a wicked problem, with a new role for policy and science. In doing so, the so-called 'A + B' political problem statement of scientifically proven safety *plus* individual freedom of choice is in itself revised and redefined, to become more inclusive of the diversity in existing arguments. This problem structuring is about articulating roles, generating trust and

deliberating about problem definitions and solutions. Spaces like these are needed, because there can be no simple or straightforward top-down solutions to this conflict.

(9) Instead of focusing on a *transfer of power* (e.g. through participatory democracy), an important way forward could be to focus on the *transformation of power*, which aims to produce a particular kind of human subject in relation to technology. Freedom of choice then no longer just implies having options, but refers instead to an understanding of the moral subject that new technologies and power structures generate.

(10) We also urge the improvement of future technology design to fulfil broader societal goals, by opening up basic norms and values that become self-evident either within the technology itself, or within its anticipated forms of use. Also, the niche protection functions of nurturing and empowering that are typically described as conditions for successful implementation of radical innovations, are also relevant for the successful implementation of apparently incremental innovations.

In sum, the lock-in for GM crops within EU agriculture is an interesting case from which to learn, because it provides a new perspective on future technology design and it allows for a societal reflection upon what 'our' social norms and values are, or should be in EU agriculture.

REFERENCES

Abrahamson, E. (1991). Managerial fads and fashions: the diffusion and rejection of innovations. Academy of management Review, 16(3), 586-612.

Amand-Eeckhout, L. (2012). Library of the European Parliament: fair trade in public procurement in the EU. Available at: http://www.europarl.europa.eu/RegData/bibliotheque/briefing/2012/120334/LDM_BRI(2012)120334_REV1_EN.pdf (accessed December 2015).

Ammann, K. (2014). Genomic Misconception: a fresh look at the biosafety of transgenic and conventional crops. A plea for a process agnostic regulation. New biotechnology, 31(1), 1-17.

Apel, A. (2010). The costly benefits of opposing agricultural biotechnology. New Biotechnology, 27(5), 635-640.

Arnold, E. (2004). Evaluating research and innovation policy: a systems world needs systems evaluations. Research Evaluation, 13(1), 3-17.

Arts, B., & Buizer, M. (2009). Forests, discourses, institutions: a discursive-institutional analysis of global forest governance. Forest Policy and Economics, 11(5), 340-347.

Avelino, F. (2009). Empowerment and the challenge of applying transition management to ongoing projects. Policy Sciences, 42(4), 369-390.

Avelino, F., & Rotmans, J. (2009). Power in transition: an interdisciplinary framework to study power in relation to structural change. European Journal of Social Theory, 12(4), 543-569.

BASF (2010). European Commission approves Amflora starch potato. Available at: http://www.agro.basf.com/agr/AP-Internet/en/function/conversions:/publish/content/news_room/news/downloads/basf-european-commission-approves-amflora-starch-potato.pdf (accessed December 2015).

Batie, S. (2008). Wicked problems and applied economics. American Journal of Agricultural Economics, 90(5), 1176-1191.

Beck, U. (1992). Risk society. Towards a new modernity. Thousand Oaks, California: Sage Publications.

Beckmann, V., Soregaroli, C., & Wesseler, J. (2006). Coexistence rules and regulations in the European Union. American Journal of Agricultural Economics, 88(5), 1193-1199.

Bemefa (2011). The production and delivery of compound feed, making use of Certified Socially Responsible Soy. Available at: www.bemefa.be/Download.ashx?ID=84664 (accessed December 2015).

Benkeblia, N. (2011). Sustainable agriculture and new biotechnologies. Boca Raton/London/New York: CRC Press.

Berkhout, F., Smith, A., & Stirling, A. (2004). Socio-technological regimes and transition contexts. *In*: System innovation and the transition to sustainability: theory, evidence and policy, 48-75.

Bett, C., Ouma, J. O., & De Groote, H. (2010). Perspectives of gatekeepers in the Kenyan food industry towards genetically modified food. Food Policy, 35(4), 332-340.

Binder, C. R., Feola, G., & Steinberger, J. K. (2010). Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture. Environmental impact assessment review, 30(2), 71-81.

Blakeley, G. (2010). Governing ourselves: citizen participation and governance in Barcelona and Manchester. International Journal of Urban and Regional Research, 34(1), 130-145.

Blancke, S., Van Breusegem, F., De Jaeger, G., Braeckman, J., & Van Montagu, M. (2015). Fatal attraction: the intuitive appeal of GMO opposition. Trends in Plant Science, 20(7), 441-418.

Boon, W. P., Moors, E. H., & Meijer, A. J. (2014). Exploring dynamics and strategies of niche protection. Research Policy, 43(4), 792-803.

Bos, B. (2008). Instrumentalization theory and reflexive design in animal husbandry. Social Epistemology, 22(1), 29-50.

Bos, B., & Grin, J. (2008). "Doing" reflexive modernization in pig husbandry: the hard work of changing the course of a river. Science, Technology & Human Values, 33(4), 480-507.

Bos, B. & Grin, J. (2012). Reflexive interactive design as an instrument for dual track governance. *In*: System innovations, knowledge regimes, and design practices towards transitions for sustainable agriculture, 132-53.

Bosch, T. (2013) Leading environmental activist's blunt confession: I was completely wrong to oppose GMOs. Available at: http://www.slate.com/blogs/future_tense/2013/01/03/mark_lynas_environmentalist_who_opposed_gmos_admits_he_was_wrong.html (accessed December 2015).

Böschen, S., Kastenhofer, K., Rust, I., Soentgen, J., & Wehling, P. (2010). Scientific nonknowledge and its political dynamics: the cases of agri-biotechnology and mobile phoning. Science, Technology & Human Values, 35(6), 783-811.

Brookes, G., & Barfoot, P. (2013). The global income and production effects of genetically modified crops 1996–2011. GM crops & Food, 4(1), 74-83.

Burkhardt, J. (1988). Biotechnology, ethics, and the structure of agriculture. Agriculture and Human Values, 5(3), 53-60.

Burns, C. (2012). How and when did we get here? An historical institutionalist analysis of EU biotechnology policy. Journal of European Integration, 34(4), 341-357.

Burns, T. R., & Carson, M. (2002). Actors, paradigms, and institutional dynamics: the theory of social rule systems applied to radical reforms. *In*: Advancing Socio-Economics: An Institutionalist Perspective, 109-147.

Busch, L. (2007). Performing the economy, performing science: from neoclassical to supply chain models in the agrifood sector. Economy and Society, 36(3), 437-466.

Busch, L. (2011). The private governance of food: equitable exchange or bizarre bazaar?. Agriculture and Human Values, 28(3), 345-352.

Buttel, F. H. (1993). Ideology and agricultural technology in the late twentieth century: Biotechnology as symbol and substance. Agriculture and Human Values, 10(2), 5-15.

Camillus, J. C. (2008). Strategy as a wicked problem. Harvard Business Review, 86(5), 99-106.

Checkland, P., & Poulter, J. (2010). Soft systems methodology. *In*: Systems approaches to managing change: A practical guide, 191-242.

Coceral, Fediol & Fefac (2014). COCERAL, FEDIOL and FEFAC highly critical of the EU Commission's lack of decision concerning vital food and feed import. Available at. http://www.fefac.eu/files/55601.pdf (accessed December 2015).

Coceral, Fediol & Fefac (2015). Economic impact assessment on the European GM authorisation "opt-out" proposal. Available at: http://www.fefac.eu/file.pdf?FileID=64108&CacheMode=Fresh (accessed December 2015).

Coenen, B. (2015). De Vlaamse anti-ggo-coalitie ontleed. De historische oppositie tegen genetisch gemanipuleerde organismen (ggo's) is een smet op het blazoen van de groene beweging (in Dutch). Available at: http://de-bron.org/content/de-vlaamse-anti-ggo-coalitie-ontleed-0 (accessed December 2015).

COGEM (2009). Should EU Legislation Be Updated? Scientific developments throw new light on the process and product approaches. COGEM Report CGM/090626-03. Available at: http://www.cogem.net/index.cfm/en/publications/publicatie/should-eu-legislation-be-

updated-scientific-developments-throw-new-light-on-the-process-and-product-approaches (accessed March 2016).

Commission of the European Communities COM (85) 750 (1985). A future for Community agriculture. Commission guidelines following the consultations in connection with the Green Paper. Available at: http://ec.europa.eu/agriculture/cap-history/crisis-years-1980s/com85-750_en.pdf (accessed March 2016).

Commission of the European Communities COM (85) 333 (1985). Perspectives for the Common Agricultural Policy. Available at: http://ec.europa.eu/agriculture/cap-history/crisis-years-1980s/com85-333_en.pdf (accessed March 2016).

Commission of the European Communities COM (91) 100 (1991). The development and future of the CAP. Reflections Paper of the Commission. Available at: http://ec.europa.eu/agriculture/cap-history/1992-reform/com91-100_en.pdf (accessed March 2016).

Commission of the European Communities COM (91) 258 (1991). The development and future of the Common Agricultural Policy. Follow-up to the Reflections Paper (Com (91) 100 of 1 February 1991) – Proposals of the Commission. Available at: http://ec.europa.eu/agriculture/cap-history/1992-reform/com91-258_en.pdf (accessed March 2016).

Cook, G., Pieri, E., & Robbins, P. T. (2004). 'The scientists think and the public feels': expert perceptions of the discourse of GM food. Discourse & Society, 15(4), 433-449.

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. Qualitative sociology, 13(1), 3-21.

De Krom, M. P., & Dessein, J. (2013). Multifunctionality and care farming: contested discourses and practices in Flanders. NJAS-Wageningen Journal of Life Sciences, 64, 17-24.

De Krom, M. P., Dessein, J., & Erbout, N. (2014). Understanding relations between science, politics, and the public: the case of a GM field trial controversy in Belgium. Sociologica Ruralis, 54(1), 21-39.

Dentoni, D., Hospes, O., & Ross, R. B. (2012). Managing wicked problems in agribusiness: the role of multi-stakeholder engagements in value creation. International Food and Agribusiness Management Review, 15(B), 1-12.

De Mey, K., D'Haene, K., Marchand, F., Meul, M., & Lauwers, L. (2011). Learning through stakeholder involvement in the implementation of MOTIFS: an integrated assessment model

for sustainable farming in Flanders. International Journal of Agricultural Sustainability, 9(2), 350-363.

Devos, Y., Demont, M., & Sanvido, O. (2008). Coexistence in the EU - return of the moratorium on GM crops?. Nature Biotechnology, 26(11), 1223-1225.

Devos, Y., Reheul, D., De Waele, D., & Van Speybroeck, L. (2006). The interplay between societal concerns and the regulatory frame on GM crops in the European Union. Environmental Biosafety Research, 5(3), 127-149.

Devos, Y., Sanvido, O., Tait, J., & Raybould, A. (2014). Towards a more open debate about values in decision-making on agricultural biotechnology. Transgenic Research, 23(6), 933-943.

Dibden, J., Gibbs, D., & Cocklin, C. (2013). Framing GM crops as a food security solution. Journal of Rural studies, 29, 59-70.

Driessen, C., & Heutinck, L. F. (2015). Cows desiring to be milked? Milking robots and the co-evolution of ethics and technology on Dutch dairy farms. Agriculture and Human Values, 32(1), 3-20.

Dryzek, J. S. (2010). Foundations and frontiers of deliberative governance. Oxford, United Kingdom: Oxford University Press.

EFSA (2011). EFSA publishes general guidance on 90-day feeding studies on whole food and feed. Available at: http://www.efsa.europa.eu/en/press/news/111207 (accessed December 2015).

EFSA (2012). Séralini et al. study conclusions not supported by data, says EU risk assessment community. Available at: http://www.efsa.europa.eu/en/press/news/121128 (accessed December 2015).

Ellis, F., & Biggs, S. (2001). Evolving themes in rural development 1950s-2000s. Development policy review, 19(4), 437-448.

Elsevier (2013). Elsevier announces article retraction from Journal Food and Chemical Toxicology. Available at: https://www.elsevier.com/about/press-releases/research-and-journals/elsevier-announces-article-retraction-from-journal-food-and-chemical-toxicology (accessed March 2016).

Elzen, B., Geels, F. W., Leeuwis, C., & van Mierlo, B. (2011). Normative contestation in transitions 'in the making': Animal welfare concerns and system innovation in pig husbandry. Research Policy, 40(2), 263-275.

EU (Commission of the European Communities) (2000) Communication on the Precautionary Principle. Available at: http://europa.eu.int (accessed December 2015).

EU Legislation in Progress - Briefing (2015). Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EC) No 1829/2003 as regards the possibility for the Member States to restrict or prohibit the use of genetically modified food and feed on their territory. Available at: http://www.europarl.europa.eu/EPRS/EPRS-Briefing-564394-Imports-GM-food-and-feed-FINAL.pdf (accessed December 2015).

Europabio (2014). Revision of the GMO Directive: a *de facto* renationalization. Available at: http://www.europabio.org/news/revision-gmo-directive-de-facto-renationalisation (accessed December 2015).

Europabio (2015). Why are farmers planting GM crops. Available at: http://www.europabio.org/why-are-farmers-planting-gm-crops (accessed December 2015).

European Commission (2005). The 2003 CAP reform. Information sheets. Available at: http://bookshop.europa.eu/is-bin/INTERSHOP.enfinity/WFS/EU-Bookshop-Site/en_GB/-/EUR/ViewPublication-Start?PublicationKey=KF6004733&CatalogCategoryID=un8KABstLQ4AAAEjIYcY4e5K (accessed March 2016).

European Commission (2015a). The European Union has established a legal framework to ensure that the development of modern biotechnology, and more specifically of GMOs, takes place in safe conditions (last update 16/10/2015). Available at: http://ec.europa.eu/food/plant/gmo/legislation/index_en.htm (accessed December 2015).

European Commission (2015b). Fact Sheet: Questions and answers on EU's policies on GMOs. Available at: http://europa.eu/rapid/press-release_MEMO-15-4778_en.htm (accessed December 2015).

European Commission (2015c). History of the CAP. Available at: http://ec.europa.eu/agriculture/cap-history/crisis-years-1980s/index_en.htm (accessed March 2016).

European Commission (2016a). New Plant Breeding Techniques. Available at: http://ec.europa.eu/food/plant/gmo/legislation/plant_breeding/index_en.htm (accessed March 2016).

European Commission (2016b). Public consultations. Available at: http://ec.europa.eu/food/plant/gmo/public_consultations/index_en.htm (accessed March 2016).

European Commission Press Release (2010). Commission announces upcoming proposal on choice for Member States to cultivate or not GMO's and approves 5 decisions on GMO's. Available at: http://europa.eu/rapid/press-release_IP-10-222_en.htm (accessed December 2015).

European Parliament (2016). European Parliament resolution on the draft Commission implementing decision authorising the placing on the market of products containing, consisting of, or produced from genetically modified soybean MON 87708 × MON 89788 (MON-877Ø8-9 × MON-89788-1) pursuant to Regulation (EC) No 1829/2003 of the European Parliament and of the Council. Available at: http://www.europarl.europa.eu/sides/getDoc.do?type=MOTION&reference=B8-2016-0134&language=EN (accessed March 2016).

European Parliament (2014). European Parliament resolution of 16 January 2014 on the proposal for a Council decision concerning the placing on the market for cultivation, in accordance with Directive 2001/18/EC of the European Parliament and of the Council, of a maize product (Zea mays L., line 1507) genetically modified for resistance to certain lepidopteran pests. Available at: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P7-TA-2014-0036+0+DOC+XML+V0//EN (accessed March 2016).

European Commission Press Release (2013). The General Court has annulled the Commission's decisions concerning authorisation to place on the market the genetically modified potato Amflora. Available at: http://europa.eu/rapid/press-release_CJE-13-160_en.htm (accessed December 2015).

European Parliament News (2015). Parliament rejects national GMO bans proposal. Available at: http://www.europarl.europa.eu/news/en/news-room/20151022IPR98805/Parliament-rejects-national-GMO-bans-proposal (accessed December 2015).

Feder, G., & Umali, D. L. (1993). The adoption of agricultural innovations: a review. Technological Forecasting and Social Change, 43(3), 215-239.

Feenberg, A. (1991). Critical theory of technology. Oxford, United Kingdom: Oxford University Press.

Feenberg, A. (2002). Transforming technology: A critical theory revisited. Oxford, United Kingdom: Oxford University Press.

Feenberg, A. (2005). Critical Theory of Technology: An overview. Tailoring Biotechnologies, 1 (1), 47-64.

Feenberg, A. (2009). Peter-Paul Verbeek: review of what things do. Human Studies, 32(2), 225-228.

Feenberg, A. (2009). Peter-Paul Verbeek: review of what things do. Human Studies, 32(2), 225-228.

Fischer, K., Ekener-Petersen, E., Rydhmer, L., & Björnberg, K. E. (2015). Social impacts of GM crops in agriculture: a systematic literature review. Sustainability, 7(7), 8598-8620.

Food and Chemical Toxicology Journal Statement (2013). Available at: http://cdn.elsevier.com/promis_misc/food_and_chemical_toxicology_homepage_statement.pdf (accessed December 2015).

Food and Chemical Toxicology (2013). All Letters to the Editor and the response. Food and Chemical Toxicology, 53 (1), 440-483.

François, K. (2011). In-between science and politics. Foundations of Science, 16(2-3), 161-171.

Fuchs, D., Kalfagianni, A., & Havinga, T. (2011). Actors in private food governance: the legitimacy of retail standards and multistakeholder initiatives with civil society participation. Agriculture and Human Values, 28(3), 353-367.

Fuenfschilling, L., & Truffer, B. (2014). The structuration of socio-technical regimes—Conceptual foundations from institutional theory. Research Policy, 43(4), 772-791.

Garud, R., Kumaraswamy, A., & Karnøe, P. (2010). Path dependence or path creation?. Journal of Management Studies, 47(4), 760-774.

Gaugitsch, H. & Heissenberger, A. (2012). Comparison of regulatory frameworks of Austria, Germany, France, and South Tyrol for GM free labeling of food products, Umweltbundesamt report. Available at: http://www.umweltbundesamt.at/en/ (accessed December 2015).

Geelhoed, M. (2014). A Growing Impasse: The Future of the EU's GMO Regime. Europa Working Paper No 2014/08. Available at: http://ssrn.com/abstract=2524340 or http://dx.doi.org/10.2139/ssrn.2524340 (accessed March 2016).

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy, 31(8), 1257-1274.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory. Research Policy, 33(6), 897-920.

Geels, F. W. (2005). Processes and patterns in transitions and system innovations: refining the co-evolutionary multi-level perspective. Technological Forecasting and Social Change, 72(6), 681-696.

Geels, F. W. (2010). Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. Research Policy, 39(4), 495-510.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: responses to seven criticisms. Environmental Innovation and Societal Transitions, 1(1), 24-40.

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. Research Policy, 36(3), 399-417.

Geels, F. W., & Verhees, B. (2011). Cultural legitimacy and framing struggles in innovation journeys: a cultural-performative perspective and a case study of Dutch nuclear energy (1945–1986). Technological Forecasting and Social Change, 78(6), 910-930.

Genus, A., & Coles, A. M. (2008). Rethinking the multi-level perspective of technological transitions. Research Policy, 37(9), 1436-1445.

Giddens, A. (1984). The constitution of society: outline of the theory of structuration. Cambridge, United Kingdom: Polity Press.

Goeminne, G. (2011). Has science ever been normal? On the need and impossibility of a sustainability science. Futures, 43(6), 627-636.

Goeminne, G. (2013). Science, technology, and the political. Techné: Research in Philosophy and Technology, 17(1), 93-123.

Goeminne, G., & Paredis, E. (2011). Opening up the in-between: Ihde's postphenomenology and beyond. Foundations of Science, 16(2), 101-107.

Gold, E. R., & Gallochat, A. (2001). The European biotech directive: past as prologue. European Law Journal, 7(3), 331-366.

Goorden, L. (2004). De Horzel en het luie paard: Over technologische groepsspurt en morele verbeelding (In Dutch). Leuven, Belgium: Uitgeverij Van Halewyck.

Gottweis, H. (2008). Participation and the new governance of life. BioSocieties, 3(3), 265-286.

Greenpeace (2014). New EU law grants countries right to ban GM crops but leaves them exposed to industry attacks. Available at: http://www.greenpeace.org/eu-unit/en/News/2014/New-EU-law-grants-countries-right-to-ban-GM-crops-but-leaves-them-exposed-to-industry-attacks-/ (accessed December 2015).

Grin, J., Felix, F., Bos, B., & Spoelstra, S. (2004). Practices for reflexive design: lessons from a Dutch programme on sustainable agriculture. International Journal of Foresight and Innovation Policy, 1(1-2), 126-149.

Grin, J., Rotmans, J., & Schot, J. (2010). Transitions to sustainable development: new directions in the study of long term transformative change. New York/London: Routledge.

Grint, K. (2005). Problems, problems, problems: the social construction of 'leadership'. Human Relations, 58(11), 1467-1494.

Gruère, G. P., Carter, C. A., & Farzin, Y. H. (2008). What labelling policy for consumer choice? The case of genetically modified food in Canada and Europe. Canadian Journal of Economics/Revue canadienne d'économique, 41(4), 1472-1497.

Gruère, G. P., & Rao, S. R. (2007). A review of international labeling policies of genetically modified food to evaluate India's proposed rule, AgBioForum, 10(1), 51-64.

Hajer, M. (1993). Discourse coalitions and the institutionalization of practice: the case of acid rain in Great Britain. *In*: The argumentative turn in policy analysis and planning, 43-76.

Hajer, M. (1995). The politics of environmental discourse: ecological modernization and the policy process. Oxford, United Kingdom: Clarendon Press.

Hajer, M., & Versteeg, W. (2005). A decade of discourse analysis of environmental politics: achievements, challenges, perspectives. Journal of Environmental Policy & Planning, 7(3), 175-184.

Hargreaves, T., Longhurst, N., & Seyfang, G. (2013). Up, down, round and round: connecting regimes and practices in innovation for sustainability. Environment and Planning A, 45(2), 402-420.

Hendry, C. (2002). Science, industry and the laity: towards a knowledgeable society for biotechnology. New Genetics and Society, 21(2), 177-198.

Hermans, F., van Apeldoorn, D., Stuiver, M., & Kok, K. (2013). Niches and networks: explaining network evolution through niche formation processes. Research Policy, 42(3), 613-623.

Herrick, C. B. (2005). 'Cultures of GM': discourses of risk and labelling of GMOs in the UK and EU. Area, 37(3), 286-294.

Hinrichs, C. C. (2014). Transitions to sustainability: a change in thinking about food systems change?. Agriculture and Human Values, 31(1), 143-155.

Hisschemöller, M., & Hoppe, R. (1995). Coping with intractable controversies: the case for problem structuring in policy design and analysis. Knowledge and Policy, 8(4), 40-60.

Hisschemöller, M., Hoppe, R., Groenewegen, P., & Midden, C. J. (2001). Knowledge use and political choice in Dutch environmental policy: a problem structuring perspective on real life experiments in extended peer review. *In*: Knowledge, power and participation in environmental policy analysis. Policy studies review annual, 437-470.

Hristova, V. (2013). Between politics and science: accommodating national diversity in GMO regulation. *In*: Balancing between trade and risk: integrating legal and social science perspectives, 107-127.

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. Qualitative Health Research, 15(9), 1277-1288.

Humphreys, D. (2009). Discourse as ideology: neoliberalism and the limits of international forest policy. Forest Policy and Economics, 11(5), 319-325.

IFOAM (2015). Parliament's Environmental Committee rejects Commission proposal on national bans for import of GMO food & feed. Available at: http://www.ifoam-eu.org/en/news/2015/10/13/parliaments-environmental-committee-rejects-commission-proposal-national-bans-import (accessed December 2015).

Ihde, D. (1990). Technology and the lifeworld: from garden to earth. Bloomington, Indiana: Indiana University Press.

Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2014a). The non-GM crop regime in the EU: how do industries deal with this wicked problem?. NJAS-Wageningen Journal of Life Sciences, 70, 103-112.

Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2014b). The 'wickedness' of GM crop applications in the European Union. International Journal of Agricultural Management, 3(2), 67-69.

Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2015). Explaining the present GM business strategy on the EU food market: the gatekeepers' perspective. New Biotechnology, 32(1), 65-78.

In 't Veld, R. J. (2010). Knowledge democracy: Consequences for science, politics, and media. Heidelberg/Dordrecht/London/New York: Springer.

ISAAA (1991). ISAAA in brief. Mission. Available at: http://www.isaaa.org/inbrief/default.asp. (accessed December 2015).

James, C. 2014. Global status of commercialized biotech/GM crops: 2014. ISAAA Brief No. 49. Available at: http://www.isaaa.org/resources/publications/briefs/49/ (accessed December 2015).

James, C., & Krattiger, A. F. (1996). Global review of the field testing and commercialization of transgenic plants: 1986 to 1995. ISAAA Briefs, 1. Available at: http://www.isaaa.org/resources/publications/briefs/01/download/isaaa-brief-01-1996.pdf (accessed December 2015).

Jensen, K. K. (2006). Conflict over risks in food production: A challenge for democracy. Journal of Agricultural and Environmental Ethics, 19(3), 269-283.

Jensen, K. K., Gamborg, C., Madsen, K. H., Jørgensen, R. B., Folker, A. P., & Sandøe, P. (2003). Making the EU "Risk Window" transparent: The normative foundations of the environmental risk assessment of GMOs. Environmental Biosafety Research, 2(3), 161-171.

Jensen, K. K., & Sandøe, P. (2002). Food safety and ethics: the interplay between science and values. Journal of Agricultural and Environmental Ethics, 15(3), 245-253.

Joly, P. B., & Lemarié, S. (1999). Industry consolidation, public attitude, and the future of plant biotechnology in Europe. Available at: http://agbioforum.org/v1n2/v1n2a10-joly.pdf (accessed December 2015).

Kalaitzandonakes, N., & Bijman, J. (2003). Who is driving biotechnology acceptance?. Nature Biotechnology, 21(4), 366-369.

Kaplan, D. M. (2009). What things still don't do. Human studies, 32(2), 229-240.

Kastenhöfer, K. (2011). Risk assessment of emerging technologies and post-normal science. Science, Technology & Human Values, 36(3), 307-333.

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. Technology Analysis & Strategic Management, 10(2), 175-198.

Klika, C., Kim, J., & Versluis, E. (2013). Why science cannot tame politics: The new EU comitology rules and the centralised authorisation procedure of GMOs. European Journal of Risk Regulation, 4(3), 327-334.

Kloppenburg, J. R. (2005). First the seed: the political economy of plant biotechnology. Madison, Wisconsin: University of Wisconsin Press.

Klümper, W. & Qaim, M. (2014) A meta-analysis of the impacts of genetically modified crops. PLoS ONE, 9(11), e111629.

Knack (2011). Actievoerders veldproef vervolgd voor bendevorming (In Dutch). Available at: http://www.knack.be/nieuws/wetenschap/actievoerders-veldproef-vervolgd-voor-bendevorming/article-normal-23168.html (accessed December 2015).

Knight, J. G., & Gao, H. (2009). Chinese gatekeeper perceptions of genetically modified food. British Food Journal, 111(1), 56-69.

Knight, J. G., Holdsworth, D. K., & Mather, D. W. (2008). GM food and neophobia: connecting with the gatekeepers of consumer choice. Journal of the Science of Food and Agriculture, 88(5), 739-744.

Koenig, A., Kleter, G.A., Hammes, W., Knudsen, I. & Kuiper, H.A. (2004). Genetically modified crops in the EU: food safety assessment, regulations and public concerns. Overarching report Entransfood, the European network on safety assessment of genetically modified food crops 2000-03. Available at: http://edepot.wur.nl/154198 (accessed December 2015).

Krimsky, S. (2005). From Asilomar to industrial biotechnology: risks, reductionism and regulation. Science as Culture, 14(4), 309-323.

Kritikos, M. (2009). Traditional risk analysis and releases of GMOs into the European Union: Space for non-scientific factors?. European law review, 34(3), 405-432.

Labrecque, J., Charlebois, S., & Spiers, E. (2007). Can genetically modified foods be considered as a dominant design? An actor-network theory investigation of gene technology in agribusiness. British Food Journal, 109(1), 81-98.

Laidlaw, J. (2002). For an anthropology of ethics and freedom. Journal of the Royal Anthropological Institute, 8(2), 311-332.

Lemmens, P. (2014). Re-taking care: open source biotech in light of the need to deproletarianize agricultural innovation. Journal of agricultural and environmental ethics, 27(1), 127-152.

Leveson, N. G. (2011). Applying systems thinking to analyze and learn from events. Safety Science, 49(1), 55-64.

Lieberman, M. B., & Asaba, S. (2006). Why do firms imitate each other?. Academy of Management Review, 31(2), 366-385.

Lieberman, S., & Gray, T. (2006). The so-called 'moratorium' on the licensing of new genetically modified (GM) products by the European Union 1998–2004: a study in ambiguity. Environmental Politics, 15(4), 592-609.

Lim, X. (2014). Seed patent primer: Is the use of GMOs preventing farmers from reusing their seeds? Available at: https://www.geneticliteracyproject.org/2014/10/21/seed-patent-primer-is-the-use-of-gmos-preventing-farmers-from-reusing-their-seeds/ (accessed December 2015).

Loeber, A. (2007). Designing for phronèsis: experiences with transformative learning on sustainable development. Critical Policy Analysis, 1(4), 389-414.

Loorbach, D. (2010). Transition management for sustainable development: a prescriptive, complexity-based governance framework. Governance, 23(1), 161-183.

Lynas, M. (2013). Time to call out the anti-GMO conspiracy theory. Available at: http://www.marklynas.org/2013/04/time-to-call-out-the-anti-gmo-conspiracy-theory/#sthash.Pu7GC3Ac.dpuf;ook (accessed December 2015).

Madsen, K. H., & Sandøe, P. (2005). Ethical reflections on herbicide-resistant crops. Pest management science, 61(3), 318-325.

Maeseele, P. (2009). NGOs and GMOs: a case study in alternative science communication. Journal of the European Institute for Communication and Culture, 16(4), 55-72.

Maeseele, P. (2011). On news media and democratic debate: framing agricultural biotechnology in Northern Belgium. International Communication Gazette, 73(1-2), 83-105.

Maeseele, P. (2013). Risk conflicts, critical discourse analysis and media discourses on GM crops and food. Journalism, 1464884913511568.

Maeseele, P., Hendrickx, K., Pavone, V., & Van Hoyweghen, I. (2013). Bio-objects' political capacity: a research agenda. Croatian medical Journal, 54(2), 206-211.

Mannion, A. M., & Morse, S. (2013). GM crops 1996-2012: a review of agronomic, environmental and socio-economic impacts. Available at: https://www.surrey.ac.uk/ces/files/pdf/04-13%20Morse_Mannion_GM%20Crops.pdf (accessed December 2015).

Masip, G., Sabalza, M., Pérez-Massot, E., Banakar, R., Cebrian, D., Twyman, R. M., ... & Christou, P. (2013). Paradoxical EU agricultural policies on genetically engineered crops. Trends in Plant Science, 18(6), 312-324.

Mathijs, E., Nevens, F., Vandenbroeck, P., & Vander Putten, E. (2012). Transitie naar een duurzaam landbouw-en voedingssysteem in Vlaanderen: een systeemanalyse. Vlaamse Milieumaatschappij. MIRA – AMS Topicrapport. Available at : http://www.milieurapport.be/Upload/main/0_topicrapporten/Topicrapport%20LV_Web.pdf. (accessed December 2015).

McHughen, A., & Wager, R. (2010). Popular misconceptions: agricultural biotechnology. New Biotechnology, 27(6), 724-728.

Meghani, Z. (2008). Values, technologies, and epistemology. Agriculture and Human Values, 25(1), 25-34.

Meyer, G. (2006). Journalism and science: How to erode the idea of knowledge. Journal of Agricultural and Environmental Ethics, 19(3), 239-252.

Michelsen, J. (2009). The Europeanization of organic agriculture and conflicts over agricultural policy. Food Policy, 34(3), 252-257.

Midgley, M. (2000). Biotechnology and monstrosity: why we should pay attention to the "yuk factor". Hastings Center Report, 30(5), 7-15.

Miller, H. I. (2010). The regulation of agricultural biotechnology: science shows a better way. New Biotechnology, 27(5), 628-634.

Morris, S. & Spillane, C. (2011). EU GM Crop Regulation: a road to resolution or a regulatory roundabout? European Journal of Risk Regulation, 4, 359-369.

Mortelmans, D. (2007). Handboek kwalitatieve onderzoeksmethoden. Leuven/Voorburg: Acco.

Myhr, A. I. (2007). The Precautionary Principle in GMO regulations. *In*: Biosafety first: holistic approaches to risk and uncertainty in genetic engineering and genetically modified organisms, 457-468.

Myhr, A. I., & Traavik, T. (2002). The precautionary principle: scientific uncertainty and omitted research in the context of GMO use and release. Journal of Agricultural and Environmental Ethics, 15(1), 73-86.

Nap, J. P., Metz, P. L., Escaler, M., & Conner, A. J. (2003). The release of genetically modified crops into the environment. The Plant Journal, 33(1), 1-18.

Naturalnews (2013). BASF gives up seeking approval for GMO potatoes in Europe. Available at: http://buzz.naturalnews.com/000831-GMO_potatoes-GMO_crops-genetically_modified.html (accessed December 2015).

Nature.com (2014). Paper claiming GM link with tumours republished. Available at: http://www.nature.com/news/paper-claiming-gm-link-with-tumours-republished-1.15463 (accessed December 2015).

Nevens, F., Mathijs, E., & Vandenbroeck, P. (2016). From systematic to systemic. An experiment in systems analysis for agriculture and food. *In*: Farming System Innovations for Sustainable Agriculture, in press.

NTB Platform (2013). Legal briefing paper. The regulatory status of plants resulting from New Breeding Technologies. Available at: https://www.infogm.org/IMG/pdf/nbt-plateform_statut-ogm_avril2014.pdf (accessed March 2016).

Onwuegbuzie, A. J., & Leech, N. L. (2007). A call for qualitative power analyses. Quality & Quantity, 41(1), 105-121.

Otero, G. (2012). The neoliberal food regime in Latin America: state, agribusiness transnational corporations and biotechnology. Canadian Journal of Development Studies/Revue canadienne d'études du développement, 33(3), 282-294.

Pechlaner, G. (2010). The sociology of agriculture in transition: the political economy of agriculture after biotechnology. Canadian Journal of Sociology/Cahiers canadiens de sociologie, 35(2), 243-269.

Pechlaner, G. (2012). Corporate crops: Biotechnology, agriculture, and the struggle for control. Austin, Texas: University of Texas Press.

Pellizzoni, L. (2010). Risk and responsibility in a manufactured world. Science and Engineering Ethics, 16(3), 463-478.

Pellizzoni, L. (2011). Governing through disorder: neoliberal environmental governance and social theory. Global Environmental Change, 21(3), 795-803.

Pesch, U. (2015). Tracing discursive space: agency and change in sustainability transitions. Technological Forecasting and Social Change, 90(B), 379-388.

Popoff, M., Moore, P., & Wager, R. (2013). Organic versus GMO: why the debate? Available at: http://www.geneticliteracyproject.org/2013/10/15/organics-versus-gmo-why-the-debate/ (accessed March 2016).

Poppe, K. J., Termeer, C., & Slingerland, M. (2009). Sustainable agriculture and food chains in peri-urban areas. Wageningen, The Netherlands: Wageningen Academic Publishers.

Potter, C., & Tilzey, M. (2005). Agricultural policy discourses in the European post-Fordist transition: neoliberalism, neomercantilism and multifunctionality. Progress in Human geography, 29(5), 581-600.

Price, B. (2014). Reductionist thinking and GMOs. Available at: http://www.biofortified.org/2014/03/reductionist-thinking-and-gmos/ (accessed December 2015).

Ramessar, K., Capell, T., Twyman, R. M., & Christou, P. (2010). Going to ridiculous lengths: European coexistence regulations for GM crops. Nature biotechnology, 28(2), 133-136.

Rao, M. B., Jongerden, J., Lemmens, P., & Ruivenkamp, G. (2015). Technological mediation and power: Postphenomenology, critical theory, and autonomist Marxism. Philosophy & Technology, 28(3), 449-474.

Raven, R., Kern, F., Verhees, B., & Smith, A. (2015). Niche construction and empowerment through socio-political work. A meta-analysis of six low-carbon technology cases. Environmental Innovation and Societal Transitions, pg. 1-17.

Regulation (EU) No 503/2013. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:157:0001:0048:EN:PDF (accessed December 2015).

Regulation (EU) No 619/2011 (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. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:166:0009:0015:EN:PDF (accessed December 2015).

Reussir.fr (2015). Restrictions sur les OGM: au tour des importations. Available at: http://grandes-cultures.reussir.fr/actualites/restrictions-sur-les-ogm-au-tour-des-importations:UY59NRO9.html (accessed December 2015).

Ricroch, A., Bergé, J. B., & Kuntz, M. (2010). Is the German suspension of MON810 maize cultivation scientifically justified?. Transgenic Research, 19(1), 1-12.

Rijke, J., Brown, R., Zevenbergen, C., Ashley, R., Farrelly, M., Morison, P., & van Herk, S. (2012). Fit-for-purpose governance: a framework to make adaptive governance operational. Environmental Science & Policy, 22, 73-84.

Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. Policy Sciences, 4(2), 155-169.

Roberts, N. (2000). Wicked problems and network approaches to resolution. International Public Management Review, 1(1), 1-19.

Roep, D., Van Der Ploeg, J. D., & Wiskerke, J. S. C. (2003). Managing technical–institutional design processes: some strategic lessons from environmental co-operatives in the Netherlands. NJAS–Wageningen Journal of Life Sciences, 51(1-2), 195-217.

Roff, R. J. (2009). No alternative? The politics and history of non-GMO certification. Agriculture and Human Values, 26(4), 351-363.

Rosendal, G. K. (2005). Governing GMOs in the EU: a deviant case of environmental policy-making?. Global Environmental Politics, 5(1), 82-104.

RT America (2015). Two thirds of EU states reject GMO crops, file cultivation opt-out requests. Available at: https://www.rt.com/news/317638-eu-gmo-cultivation-opt-out/ (accessed December 2015).

Ruivenkamp, G., Hisano, S., & Jongerden, J. (2008). Reconstructing biotechnologies. Critical social analyses. Wageningen, The Netherlands: Wageningen Academic Publishers.

Saldana, J. (2009). An introduction to codes and coding. The coding manual for qualitative researchers. Available at: http://www.sagepub.com/sites/default/files/upm-binaries/24614_01_Saldana_Ch_01.pdf (accessed December 2015).

Sapsford, R., & Jupp, V. (2006). Data Collection and Analysis. *In*: Statistical Techniques, 208-243.

Schot, J., & Geels, F. W. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. Technology Analysis & Strategic Management, 20(5), 537-554.

Schuitmaker, T. J. (2012). Identifying and unravelling persistent problems. Technological Forecasting and Social Change, 79(6), 1021-1031.

Scoones, I., Leach, M., Smith, A., Stagl, S., Stirling, A., & Thompson, J. (2007). Dynamic systems and the challenge of sustainability, STEPS working paper, STEPS Centre, Brighton.

Scott, I. M. (2000). Green symbolism in the genetic modification debate. Journal of Agricultural and Environmental Ethics, 13(3-4), 293-311.

Séralini, G. E., Clair, E., Mesnage, R., Gress, S., Defarge, N., Malatesta, M., ... & De Vendômois, J. S. (2012). *Retracted*: Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize. Food and Chemical Toxicology, 50(11), 4221-4231.

Séralini, G. E., Clair, E., Mesnage, R., Gress, S., Defarge, N., Malatesta, M., ... & de Vendômois, J. S. (2014). *Republished study*: Long-term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize. Environmental Sciences Europe, 26(1), 14.

Sewell Jr, W. H. (1992). A theory of structure: duality, agency, and transformation. American Journal of Sociology, 98(1), 1-29.

Shaffer, G., & Pollack, M. (2004). Regulating between national fears and global disciplines: Agricultural biotechnology in the EU (No. 10). Jean Monnet Working Paper. Available at: http://www.jeanmonnetprogram.org/archive/papers/04/041001.pdf (accessed March 2016).

Silva, J. S. (1988). The contradictions of the biorevolution for the development of agriculture in the third world: Biotechnology and capitalist interest. Agriculture and Human Values, 5(3), 61-70.

Skogstad, G. (2011). Contested accountability claims and GMO regulation in the European Union. JCMS: Journal of Common Market Studies, 49(4), 895-915.

Smith, A. (2006). Green niches in sustainable development: the case of organic food in the United Kingdom. Environment and Planning C: Government and Policy, 24(3), 439-458.

Smith, A. (2007). Translating sustainabilities between green niches and socio-technical regimes. Technology Analysis & Strategic Management, 19(4), 427-450.

Smith, A., & Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. Research Policy, 41(6), 1025-1036.

Smith, A., Stirling, A., & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. Research Policy, 34(10), 1491-1510.

Smith, A., Voß, J. P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. Research policy, 39(4), 435-448.

Smits, M. (2006). Taming monsters: The cultural domestication of new technology. Technology in Society, 28(4), 489-504.

Sneddon, J., Soutar, G., & Mazzarol, T. (2011). Modelling the faddish, fashionable and efficient diffusion of agricultural technologies: a case study of the diffusion of wool testing technology in Australia. Technological Forecasting and Social Change, 78(3), 468-480.

Stein, A. J., & Rodríguez-Cerezo, E. (2010). International trade and the global pipeline of new GM crops. Nature Biotechnology, 28(1), 23-25.

Stemler, S. (2001). An overview of content analysis. Practical assessment, research & evaluation, 7(17), 137-146.

Stephan, H. R. (2012). Revisiting the transatlantic divergence over GMOs: toward a cultural-political analysis. Global Environmental Politics, 12(4), 104-124.

Stewart, P. A., & McLean, W. P. (2005). Public opinion toward the first, second, and third generations of plant biotechnology. In Vitro Cellular & Developmental Biology-Plant, 41(6), 718-724.

Stolze, M., & Lampkin, N. (2009). Policy for organic farming: rationale and concepts. Food Policy, 34(3), 237-244.

Sung, B., & Hwang, K. (2013). Firms' intentions to use genetically modified organisms industrially: the influence of sociopolitical-economic forces and managerial interpretations in the Korean context. Technological Forecasting and Social Change, 80(7), 1387-1394.

Swierstra, T., Boenink, M., Walhout, B., & Van Est, R. (2009). Converging technologies, shifting boundaries. NanoEthics, 3(3), 213-216.

Swierstra, T., & Rip, A. (2007). Nano-ethics as NEST-ethics: patterns of moral argumentation about new and emerging science and technology. NanoEthics, 1(1), 3-20.

Swierstra, T., & Waelbers, K. (2012). Designing a good life: A matrix for the technological mediation of morality. Science and Engineering Ethics, 18(1), 157-172.

Swinnen, J. F., & Vandemoortele, T. (2010). Policy gridlock or future change? The political economy dynamics of EU biotechnology regulation. AgBioForum, 13(4), 291-296.

Tait, J., & Barker, G. (2011). Global food security and the governance of modern biotechnologies. EMBO reports, 12(8), 763-768.

Tesch, R. (1990). Qualitative research: Analysis types and software tools. Bristol, PA: Falmer.

Thrane, S., Blaabjerg, S., & Møller, R. H. (2010). Innovative path dependence: making sense of product and service innovation in path dependent innovation processes. Research Policy, 39(7), 932-944.

Tosun, J. (2014). Agricultural biotechnology in Central and Eastern Europe: determinants of cultivation bans. Sociologia Ruralis, 54(3), 362-381.

Triste, L., Marchand, F., Debruyne, L., Meul, M., & Lauwers, L. (2014). Reflection on the development process of a sustainability assessment tool: learning from a Flemish case. Ecology and Society, 19(3).

Turnheim, B., & Geels, F. W. (2012). Regime destabilisation as the flipside of energy transitions: lessons from the history of the British coal industry (1913–1997). Energy Policy, 50, 35-49.

Turnheim, B., & Geels, F. W. (2013). The destabilisation of existing regimes: Confronting a multi-dimensional framework with a case study of the British coal industry (1913–1967). Research Policy, 42(10), 1749-1767.

Tyfield, D. (2014). Putting the power in 'socio-technical regimes'–E-mobility transition in China as political process. Mobilities, 9(4), 585-603.

Vaeck, M., Reynaerts, A., Höfte, H., Jansens, S., De Beuckeleer, M., Dean, C., ... & Leemans, J. (1987). Transgenic plants protected from insect attack. Nature, 328, 33-37.

van Buuren, A., & Edelenbos, J. (2004). Why is joint knowledge production such a problem?. Science and Public Policy, 31(4), 289-299.

Van den Burg, S. (2006). Governance through information. Environmental monitoring from a citizen consumer perspective. PhD dissertation. Wageningen University, The Netherlands. Available at: http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=C8155995658D59B10D8B88A073473A21?doi=10.1.1.117.3086&rep=rep1&type=pdf (accessed December 2015).

Van Den Eede, Y. (2011). In between us: on the transparency and opacity of technological mediation. Foundations of Science, 16(2-3), 139-159.

Van Den Eede, Y., Goeminne, G., & Van den Bossche, M. (2015). The Art of Living with Technology: Turning Over Philosophy of Technology's Empirical Turn. Foundations of Science, 1-12.

Van de Poel, I., & Verbeek, P. P. (2006). Editorial: ethics and engineering design. Science, Technology & Human Values, 31(3), 223-236.

van Eeten, M. J. (1999). 'Dialogues of the deaf' on science in policy controversies. Science and Public Policy, 26(3), 185-192.

Van Haperen, P. V., Gremmen, B., & Jacobs, J. (2012). Reconstruction of the ethical debate on naturalness in discussions about plant-biotechnology. Journal of Agricultural and Environmental Ethics, 25(6), 797-812.

Vanclay, F. M., Russell, A. W., & Kimber, J. (2013). Enhancing innovation in agriculture at the policy level: the potential contribution of Technology Assessment. Land Use Policy, 31, 406-411.

Vandenbroeck, P. (2012). Working with wicked problems. Available at: http://www.kbs-frb.be/publication.aspx?id=303257&langtype=1033(accessed December 2015).

Vanloqueren, G., & Baret, P. V. (2009). How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations. Research Policy, 38(6), 971-983.

Verbeek, P. P. (2006a). Materializing morality design ethics and technological mediation. Science, Technology & Human Values, 31(3), 361-380.

Verbeek, P. P. (2006b). Persuasive Technology and Moral Responsibility Toward an ethical framework for persuasive technologies. Persuasive, 6, 1-15.

Verbeek, P. P. (2008a). De grens van de mens. Over techniek, ethiek en de menselijke natuur (In Dutch). Rotterdam, The Netherlands: Lemniscaat.

Verbeek, P. P. (2008b). Obstetric ultrasound and the technological mediation of morality: A postphenomenological analysis. Human Studies, 31(1), 11-26.

Verbeek, P. P. (2011). Moralizing technology: understanding and designing the morality of things. Chicago/London: University of Chicago Press.

Verbeek, P. P. (2012). Expanding mediation theory. Foundations of Science, 17(4), 391-395.

Verbeek, P. P. (2013). Resistance is futile. Techne: research in philosophy and technology, 17(1), 72-92.

Verbeek, P.P. (2014). Op de vleugels van Icarus: hoe techniek en moraal met elkaar meebewegen (In Dutch). Rotterdam, The Netherlands: Lemniscaat.

Verhees, B., Raven, R., Kern, F., & Smith, A. (2015). The role of policy in shielding, nurturing and enabling offshore wind in The Netherlands (1973–2013). Renewable and Sustainable Energy Reviews, 47, 816-829.

VIB (Vlaams Instituut voor Biotechnologie) (2014). Fact series. Een schimmel-resistente aardappel voor België (in Dutch). Available at: http://www.vib.be/nl/educatie/Documents/VIB_dossier_%20schimmelresistente%20aardappel.pdf (accessed March 2016).

VILT (2011). Actievoerders vernielen ggo-aardappelveld in Wetteren (In Dutch). Available at: http://www.vilt.be/Actievoerders_vernielen_ggo_aardappelveld_in_Wetteren (accessed December 2015).

VILT (2012). BASF stopt met ontwikkeling ggo's voor Europese markt (In Dutch). Available at: http://www.vilt.be/BASF_stopt_met_ontwikkeling_ggos_voor_Europese_markt (accessed December 2015).

VILT (2016). Versoepeling ggo-wetgeving schendt voorzorgsprincipe (in Dutch). Available at: http://www.vilt.be/versoepeling-ggo-wetgeving-schendt-voorzorgsprincipe (accessed March 2016).

Waelbers, K. (2009). From assigning to designing technological agency. Human Studies, 32(2), 241-250.

Wesselink, A., & Hoppe, R. (2011). If post-normal science is the solution, what is the problem? The politics of activist environmental science. Science, Technology & Human Values, 36(3), 389-412.

Wetenschappelik Instituut Volksgezondheid (WIV) - Institut Scientifique De Santé Publique. 2010. 1990-2010: Twenty years of risk-assessment of GMOs and pathogens. Available at: http://www.biosafety.be/Book/PDF/SBB_20jaarBioveiligheid_NL_HR.pdf (accessed December 2015).

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2011). Agroecology as a science, a movement and a practice. *In*: Sustainable agriculture volume 2, 27-43.

Whyte, K. P. (2015). What is multistability? A theory of the keystone concept of postphenomenological research. *In*: Technoscience and postphenomenology: The manhattan papers, 69-81.

Wield, D., Chataway, J., & Bolo, M. (2010). Issues in the political economy of agricultural biotechnology. Journal of Agrarian Change, 10(3), 342-366.

Wilkinson, J. (2002). The final foods industry and the changing face of the global agro–food system. Sociologia Ruralis, 42(4), 329-346.

Whitmarsh, L. (2012). How useful is the Multi-Level Perspective for transport and sustainability research?. Journal of Transport Geography, 24, 483-487.

Wright, O. (2015). Ex-Greenpeace director denounces 'immoral' groups that campaign against GM foods. Available at: http://www.independent.co.uk/environment/ex-greenpeace-director-denounces-immoral-groups-that-campaign-against-gm-foods-10306370.html (accessed December 2015).

Young, O. R., Chambers, B. W., Kim, J. A., & Ten Have, C. (2009). Institutional interplay: biosafety and trade. Tokyo/New York/Paris: United Nations University Press.

SUMMARY

There are many actors involved in the ongoing debate about genetically modified (GM) crops in the European Union. These actors have strongly divergent views and problem definitions about, for example, the ongoing privatisation in agriculture, a loss of biodiversity or aspects of scientifically proven safety of GM crops. However, none of them currently has the authority to enforce their own problem-and-solution frame. This has resulted in the current impasse for the technology, where moving forward in trying to implement GM crops has been systematically blocked, while at the same time attempts to fully exclude GM crops from EU agriculture have been systematically prevented. In order to incorporate all of the diversity present within the ongoing debate and to include the dominant rules and resources within the EU agricultural regime in our analysis of the lock-in for GM crop applications, we have used the concept of *wicked problems.* That is because this problem is both socio-political and systemic.

As a socio-political problem we analyse how the problem with GM crop applications is framed within the EU legislation and the extent to which this political problem statement could obtain social legitimacy. Wicked problems are generally characterised by strongly divergent norms and values (in this case about GM crop applications), with a high level of disagreement about the knowledge that is available and required to politically address the problem.
As systemic problems, wicked problems are reproduced by the organising structures in socio-technical systems, such as by the general perceptions and uses of science, cultural discourses, political norms or technological standards within the EU agricultural regime.

A systemic perspective on the lock-in for GM crop applications

Taking this framework of analysis, the dissertation develops a systemic perspective to understand the current lock-in for GM crop applications within the European context. We have therefore formulated two objectives. The first objective is to characterise the systemic and socially reproduced nature of the lock-in for GM crop applications. The second objective seeks to understand why the EU debate about GM crops is so strongly polarised, based largely on Yes/No questions and how this debate can be enhanced (by asking different questions). Different methodologies and theories have been used, including a discourse analysis, a content analysis, the multi-level perspective and mediation theory.

This leads us to three important angles for analysing the EU lock-in for GM crop applications. First, we have analysed how actors define and interpret the problem with GM crops, and how these

actors reproduce the lock-in within their daily practices. For this, we have identified the present discourses about GM crops within different agribusiness sectors and have defined how these have influenced their business strategy for the European market.
A second angle involves the existing structures within the EU agricultural regime, as these will codetermine how GM crops are embedded within specific user practices. Besides, as a tangible technology, a GM crop can transform unaware or 'passive' (moral) routines within the agricultural regime into 'active' ethical issues again. Of course, this technology can also further normalise certain existing rules and practices.
A third perspective for analysing the lock-in is initiated from the technology itself. This is because technologies are not just passive or neutral objects. They have a particular directedness and favour or disfavour certain action, or they show certain aspects of the world while diminishing others. A herbicide-resistant GM crop, for example, 'demands' to be sprayed and thereby favours a certain type of agricultural practice. A drought-resistant GM crop materialises 'ecological modernisation' and thereby offers a shortcut technical solution to cope with changing climatic conditions (not framing the problem as a socio-political or systemic challenge, for example). However, it is not just technological affordances that determine how a GM crop will be used. A herbicide-resistant GM crop, for example, does not automatically lead to proactive spraying sessions with that herbicide during crop cultivation. GM crops only convey meaning within their activities (by how are they used, in what type of agriculture, by what chain organisation, ….), a context of use that will, however, be directed by the materialising values within the crop. Both human and technological intentionality therefore attribute meaning to GM crops.

Several key insights to understand the current lock-in

This research points to several key aspects that can explain the existing lock-in for GM crop applications. We explain four of them.

1. A symbolic role for GM crops in the discursive battle about globalised, input-dependent agriculture.

GM crops have evolved into a symbol for the discursive battle about the existing EU agricultural regime which is dominated by a globalising, input-dependent type of agriculture: GM crops could increase the visibility and proximity of certain regime problems for actors such as citizens or consumers who are not closely involved with agriculture. Besides, the high level of normative contestation about GM crops in the EU can be explained from a historical perspective. Namely, the implementation of GM crops within the EU coincided with a number of societal evolutions within

the EU agricultural regime (such as changing societal perceptions about science or innovation) and with certain events (such as the BSE crisis and the dioxin food scandal).

2. Solely a functional, externalist view on technology.

Both proponents and opponents of GM crop applications consider technology as something 'external' to the human sphere. This is either as an instrument that has a life of its own (technological determinism), or as a neutral instrument that can be employed at will without any recursive effects on human interpretation and action (technological instrumentalism). Under this view, technology is seen as either acceptable or unacceptable *tout court*. That is why the problem is often presented as a Yes/No question, with minimal reflection about the underlying EU agricultural regime that helps to define the technology (such as which regime rules and practices GM crops normalise, or which new norms and values they introduce). Such a debate cannot offer a way forward with the current lock-in. This requires new types of question, which stimulate a new approach to technology. Questions such as: how to extend an externalist view on technology towards considering the whole sociotechnical practice that codetermines the technology; how GM crops participate in our way of life, in our agriculture; which human-world relationship these crops mediate, … etc.

3. Technology makes routines within the agricultural regime tangible, thereby transforming these into ethical issues again.

Despite the current polarisation, the GM debate in the EU is valid and relevant, because GM crops can establish certain self-evident routines within the agricultural regime, making them tangible, and thereby transforming these routines into 'active' ethical issues. For example, GM crops amplify a norm of control and controllability in agricultural production, where *expecting* a good harvest may increasingly become *choosing* a good harvest, and may therefore stigmatise a labour intensive or low-production type of agriculture that values harvests differently. GM crops can, for example, also increase awareness about the strong, ongoing privatisation of agriculture. Under this view, discussions about GM crops become an interesting way to understand and to debate, how we have organised, or want to organise, European agriculture. These examples also illustrate how ethical concerns have (co-)evolved with the material development of GM crops, whereby the debate can be understood as a consequence of the new concerns that these applications introduce and lay bare.

4. A socio-political problem: the problem statement within the EU legislation could not obtain social or political legitimacy.

To understand the lock-in for GM crop applications, we have also researched how this problem is framed within the EU GM crop legislation, as a political problem statement defines which type of arguments are legitimate within the political sphere. In general terms, an 'A + B' political problem statement is presented – where the scientifically proven safety of GM crops (component A) in combination with offering individual freedom of choice (by means of obligated traceability, GM labelling and coexistence measures: component B) forms the basis for authorising GM crops within the EU. (The recent Amendment to Directive 2001/18/EC does not change anything in terms of the general authorisation process).

In practice, the formulation of 'Implementing Acts' for GM crops by the European Commission occurs in a *depoliticised* way – only scientific arguments are considered – while the next phase of risk-management in the authorisation process takes place in a political impasse because (representatives of) Member States have, so far, been unable to adopt a position by a qualified majority either for or against the authorisation of a new GM crop for the EU market.

This political problem statement and/or the way in which it has been implemented has been unable to obtain social or political support until now. Many examples illustrate this. The recent resolution voted in the European Parliament against draft authorisation decisions for new GM crops, when the Parliament has no official role in this authorisation process. There was also the 'GM potato war' in Wetteren, and the back-and-forth process in the authorisation of Amflora, for example.

This societal and political resistance can be understood in two ways. First, by offering individual freedom of choice ethical arguments and moral concerns are transferred to the individual private sphere. The widely diverse norms and values at play in relation to GM crops have therefore been acknowledged in the political framing of the problem with GM crops in the EU, but they have little right to actually exist within the political sphere. Secondly, the current political problem statement presupposes a high level of scientific consensus about the safety of GM crops for humans, animals, and the environment. Namely, the European Commission systematically follows the opinions of EFSA when formulating Implementing Acts for GM crops. However, EFSA formulates these opinions without specifying its subjective choices regarding appropriate methodologies (e.g. holistic, reductive) and its framing of risks with GM crops. These assumptions are therefore not

open for discussion. Within this overall risk regime, non-scientific argumentations (public concerns) are reduced solely to a demand for greater safety.

We can therefore conclude that the political problem statement and its current implementation also contribute to the current lock-in for GM crop applications in the EU, in addition to all the other elements that we have identified, such as strongly divergent norms and values, the historical context, an externalist and absolutist view on technology, and the mediating role of technology within its user context.

A defensive tone in the debate

The overall tone of the GM debate in the EU is consequently defensive. This is for at least two important reasons. The first reason is the strong prioritisation of scientific facts within EU GM crop legislation, because the risk-based regulation makes non-scientific arguments peripheral and because of certain practices of depoliticisation. This creates a scenario of having to justify one's arguments in a scientifically found way to achieve political impact under the general authorisation process (followed by a political impasse). It also results in the formation of knowledge coalitions, where different actors work closely together to produce knowledge and their own facts, thereby departing from one specific scientific problem statement. Secondly, the defensive tone in the debate is the result of a strong externalist, absolutist view on technology, which considers GM crops as something external to the human sphere and this contributes to the 'take it or leave it' discussion about this technology – within a polarised Yes/No framing.

How to move forward?

This analysis suggests four paths for moving forward with the lock-in for GM crop applications:

1. It is important to ask different questions. Questions that are more expansive compared to the current Yes/No questions which are largely about the acceptability and safety of GM crops within the political sphere. Such as, how do GM crops participate in our way of life, in our agriculture, what human-world relationship do these crops mediate, … and whether these social, economic of cultural changes, for example, are desirable and needed.
2. It is relevant to introduce more room for non-scientific arguments within the overall authorisation process for GM crops in the EU (and not post-authorisation as with the recent Amendment for cultivation). This is possible by partially or extensively revising the overall 'A + B' political problem statement (safety and individual freedom of choice) as the current basis for authorising GM crops.

3. It is important to approach technology differently. Namely, from a perspective of the full user practices with the technology and with attention for technological mediation effects, rather than from an externalist view on technology (that is either instrumental, or deterministic).
4. It is important to question the role of science within political problem statements for new (agricultural) technologies. Science cannot structure every problem in the same way. The facts that science generates are also the result of a specific scientific question posed. It is therefore essential to not only include the scientific answers within a political decision-making process, but also the scientific questions at hand.

SAMENVATTING

Er zijn diverse actoren betrokken in het debat over genetisch gemodificeerde gewassen (ggo-gewassen) in de Europese Unie. Deze actoren hebben uiteenlopende visies en probleemstellingen, zoals een verregaande privatisering in de landbouw, het verlies aan biodiversiteit of de wetenschappelijk aangetoonde veiligheid van ggo-gewassen. Geen van hen heeft op dit moment echter voldoende autoriteit verworven om hun probleemdefinitie en -oplossing te kunnen afdwingen. Dit komt tot uiting in de huidige impasse waarin de technologie zit, waarbij noch het implementeren, noch het volledig bannen van deze toepassingen in de Europese landbouwpraktijken kan slagen. Om al deze complexiteit in het debat te omarmen en om de dominante regels en -praktijken binnen het Europese landbouwregime mee te nemen in onze analyse van de ggo-impasse, hebben we gewerkt met het concept van *wicked problems*. Het gaat immers om een probleem dat sociaal-politiek en systemisch is.

Als sociaal-politiek probleem analyseren we hoe ggo-gewassen gekaderd worden als probleem binnen de Europese regelgeving en de mate waarin deze politieke probleemdefinitie ook maatschappelijke legitimiteit verwerft. Wicked problems worden daarbij algemeen gekenmerkt door sterk verschillende normen en waarden (over ggo-gewassen in dit geval), met een grote onenigheid over de kennis die beschikbaar of nodig is om het probleem politiek aan te pakken.
Als systemische problemen worden wicked problems beschouwd als problemen die gereproduceerd worden door de organiserende structuren in het socio-technisch systeem, zoals door algemene opvattingen en gebruiken rond wetenschap, culturele discoursen, politieke normen of technologische standaarden in het Europese landbouwregime.

Een systemisch perspectief op de ggo-impasse

Vanuit dit analysekader wordt er in het proefschrift een systemisch perspectief opgebouwd om de impasse van ggo-gewassen in de Europese context te begrijpen. Er werden daarvoor twee objectieven gedefinieerd. Het eerste objectief is het karakteriseren van de systemische en sociaal gereproduceerde aard van de huidige impasse waarin ggo-gewassen zitten. Het tweede objectief wil begrijpen waarom het EU debat rond ggo-gewassen zo sterk gepolariseerd verloopt, in voornamelijk Ja/Neen-vraagstellingen, en hoe het verbreed kan worden (door andere vragen te stellen). Verschillende methodes en theorieën zijn hiervoor gebruikt, waaronder een discours-analyse, een 'content'-analysis, het multi-level perspectief en mediatietheorie.

Daarbij zijn drie belangrijke invalshoeken vooropgesteld om de huidige impasse te analyseren. Ten eerste bestuderen we hoe actoren het probleem met ggo-gewassen definiëren en interpreteren, en hoe deze actoren de huidige impasse mee in stand houden met hun dagdagelijkse praktijken. We hebben daarvoor de heersende discoursen over ggo-gewassen bij agribusiness-actoren geïdentificeerd en gingen na hoe deze invloed uitoefenen op hun bedrijfsvoering voor de Europese markt.
Een tweede invalshoek vertrekt vanuit de structuren in het Europese landbouwregime, omdat deze mede bepalend zullen zijn voor hoe ggo-gewassen worden ingebed in specifieke gebruikerspraktijken. Tastbare technologie, een ggo-gewas, kan bovendien onbewuste of 'passieve' (morele) routines in het landbouwregime omvormen tot 'actieve' ethische kwesties. Of omgekeerd, deze technologie kan ook bepaalde regimeregels en -praktijken gewoon verder normaliseren.
Een derde invalshoek neemt de technologie zelf als vertrekpunt. Technologieën zijn immers geen passieve of neutrale voorwerpen. Ze dragen een bepaalde gerichtheid in zich, waardoor ze bepaalde gebruiken meer of minder toelaten, of ze belichten bepaalde aspecten van de wereld meer of minder. Een herbicideresistent ggo-gewas bijvoorbeeld, 'nodigt uit' om gesproeid te worden en oriënteert de landbouwpraktijk daardoor in een bepaalde richting. Een droogte-resistent ggo-gewas materialiseert 'ecologische modernisatie', waarbij veranderende klimatologische omstandigheden vooral als een technische uitdaging worden benaderd (bijvoorbeeld niet als een sociaal-politieke of systemische uitdaging). Maar niet enkel deze bemiddelende rol van technologie bepaalt hoe een ggo-gewas gebruikt zal worden. Een herbicideresistent ggo-gewas bijvoorbeeld hoeft niet automatisch te leiden tot proactieve sproeisessies met dat herbicide. Ggo-gewassen krijgen maar betekenis als ze worden toegepast (door hoe ze worden gebruikt, in welk type landbouw, in welke ketenorganisatie,…), een gebruik dat weliswaar mee wordt aangestuurd door de materialiserende waarden in het gewas. Zowel een menselijke als technologische intentionaliteit maken bijgevolg deel uit van hoe ggo-gewassen betekenis worden verleend.

Een aantal kernpunten om de impasse te begrijpen

Dit onderzoek duidt op een aantal kernpunten om de huidige EU impasse van ggo-gewassen te verklaren. We lichten er een viertal kort toe.

1. De symbolische rol van ggo-gewassen in de discoursstrijd over geglobaliseerde, input-afhankelijke landbouw.

Ggo-gewassen zijn een symbool geworden in de discoursstrijd over het bestaande Europese landbouwregime dat voornamelijk een globaliserend, input-afhankelijk type landbouw vooropstelt: ggo-gewassen maakten regime-problemen zichtbaar en tastbaar voor actoren zoals burgers en consumenten die eerder veraf staan van de landbouw. Daarnaast kan de normatieve contestatie over ggo-gewassen in de EU deels verklaard worden vanuit een historisch perspectief. De implementering van deze gewassen viel namelijk samen met bepaalde maatschappelijke evoluties in het Europese landbouwregime (zoals veranderende maatschappelijke opvattingen rond wetenschap of innovatie) en met bepaalde gebeurtenissen (zoals de BSE-crisis of het dioxineschandaal).

2. Een louter functionele, externe visie op technologie.

Technologie wordt door zowel voor- als tegenstanders van ggo-gewassen beschouwd als zijnde 'extern' aan de menselijke sfeer. Ofwel als een instrument dat geheel een eigen leven leidt (technologisch determinisme), ofwel als een instrument dat volledig neutraal is en vrijelijk gebruikt kan worden door de mens zonder enige weerklank op ons menselijk denken en doen (technologisch instrumentalisme). Door deze houding kan de technologie alleen maar aanvaard of afgewezen worden *op zichzelf*. Daardoor wordt het probleem ook voorgesteld als een Ja/Neen-vraagstuk, met een slechts oppervlakkige reflectie over het onderliggende Europese landbouwsysteem dat de technologie mede betekenis geeft (zoals welke regime regels en -praktijken normaliseren ggo-gewassen, of welke nieuwe normen en waarden introduceren ze). Dergelijk debat biedt de huidige impasse echter geen uitweg. Hiervoor zijn immers nieuwe vragen nodig, die een andere benadering van technologie stimuleren. Vragen zoals: hoe verschuif je een externe houding ten opzichte van technologie naar aandacht voor de socio-technische praktijken die de technologie mee vorm geven; hoe geven ggo-gewassen vorm aan onze manier van leven, aan onze landbouw; welk boer-landbouw wereldbeeld mediëren ze, … enzovoort.

3. Technologie maakt bepaalde routines in het landbouwregime tastbaar, waardoor deze opnieuw ethische kwesties kunnen worden.

Ondanks de huidige polarisatie is het ggo-debat legitiem en relevant, omdat ggo-gewassen een bepaalde zelf-evidentie van routines in het landbouwregime concreet maken, een gezicht geven, en deze daardoor kunnen omvormen tot 'actieve' ethische kwesties. Ggo-gewassen presenteren

bijvoorbeeld een norm van verhoogde controleerbaarheid en controle in gewasproductie. Het *verwachten* van een goede oogst verandert daardoor deels in het *kiezen voor* een goede oogst, wat mogelijk een waardeoordeel inhoudt over andere types landbouw die bijvoorbeeld meer arbeidsintensief zijn of een lager rendement hebben. Ggo-gewassen verhogen bijvoorbeeld ook concreet het bewustzijn dat er reeds een verregaande privatisering plaatsvindt in de landbouw. Hierdoor worden discussies over ggo-gewassen een manier om te begrijpen en te debatteren over, hoe wij Europese landbouw (willen) organiseren. Deze voorbeelden tonen ook aan hoe ethische kwesties over landbouwpraktijken zijn ge(co)évolueerd met de ontwikkeling van ggo-gewassen waardoor het debat rijker kan begrepen worden, namelijk als een gevolg van nieuwe (morele) routines die deze technologische toepassingen introduceren en blootleggen.

4. Een sociaal-politiek probleem: de probleemdefinitie in de Europese ggo-regelgeving kon geen maatschappelijke of politieke legitimiteit verwerven.

Om de impasse van ggo-gewassen te begrijpen, onderzoeken we ook hoe de EU regelgeving ggo-gewassen kadert, aangezien de politieke probleemdefinitie bepalend is voor de mate waarin bepaalde types argumenten ruimte krijgen in de politieke sfeer. Hierbij wordt er algemeen een 'A + B' probleemstelling naar voor geschoven - waarbij een aangetoonde wetenschappelijke veiligheid van ggo-gewassen (component A) in combinatie met het bieden van individuele keuzevrijheid (door middel van verplichte traceerbaarheid, ggo-labels en co-existentie maatregelen: component B) samen een voldoende basis vormen om ggo-gewassen te autoriseren voor de Europese markt. (Het recent Amendement van de Richtlijn 2001/18/EC verandert niets aan de algemene autorisatieprocedure).

In de praktijk gebeurt de formulering van 'Implementing Acts' voor ggo-gewassen door de Europese Commissie echter sterk *gedepolitiseerd* – alleen wetenschappelijke argumenten worden in rekening gebracht - terwijl de vervolgfase van risicobeheer in een *politieke impasse* zit omdat (vertegenwoordigers van) de lidstaten tot zover geen gekwalificeerde meerderheidsstemmen bekomen voor of tegen het implementeren van een nieuw ggo-gewas voor de EU markt.

Deze politieke probleemstelling en/of de manier van uitvoeren kon tot op heden echter geen maatschappelijke of politieke legitimiteit verwerven. Talrijke voorbeelden illustreren dit. Het Europees Parlement stemde recent opnieuw een resolutie om Implementing Acts voor ggo-gewassen terug te trekken, terwijl het Europees Parlement geen formele rol heeft in dit autorisatieproces. Er waren ook de 'de aardappeloorlog' in Wetteren, of het heen-en-weergetrek over de autorisatie van Amflora, bijvoorbeeld.

Deze maatschappelijke en politieke weerstand kan op twee manieren begrepen worden. Ten eerste zorgt het bieden van individuele keuzevrijheid ervoor dat ethische en morele argumenten systematisch naar de individuele sfeer verschuiven. Er is bijgevolg wel politieke erkenning van de verschillende normen en waarden over ggo-gewassen in de EU, maar deze krijgen weinig bestaansrecht in de politieke ruimte. Ten tweede veronderstelt de huidige politieke probleemstelling ook een hoge mate van wetenschappelijke consensus over de veiligheid van ggo-gewassen voor mens, dier en milieu. De Europese Commissie volgt namelijk systematisch de opinies van EFSA in het formuleren van Implementing Acts. EFSA formuleert die wetenschappelijke opinies echter zonder de achterliggende assumpties of voorkeur voor bepaalde wetenschappelijke methodologieën (e.g. holistisch, reductionistisch) uit te spreken. Hierdoor kunnen deze ook geen onderwerp van debat worden. Binnen dit kader van risico-argumenten worden niet-wetenschappelijke standpunten (public concerns) dan ook herleid tot een vraag naar meer veiligheid.

Algemeen kunnen we daarom besluiten dat de politieke probleemdefinitie en -uitwerking mee aanleiding geven tot de huidige impasse van ggo-gewassen in de EU, bovenop alle andere elementen die we duidden, zoals gecontesteerde normen en waarden, de historische context, een absolute en externe houding ten opzichte van technologie, en de bemiddelende rol van technologie zelf in de gebruikscontext.

Een defensieve toon in het debat

De algemene toon van het EU-debat over ggo-gewassen is dan ook defensief. Dit heeft ten minste twee belangrijke redenen. Ten eerste wordt er een hoge prioriteit verleend aan wetenschappelijke argumenten in de Europese ggo-regelgeving, aangezien dit een risico-gebaseerde wetgeving is waarbij niet wetenschappelijke argumenten meer perifeer worden en omwille van bepaalde depolitiserende praktijken. Dit creëert een situatie waarin actoren zichzelf moeten verantwoorden met wetenschappelijk onderbouwde argumenten vooraleer ze politiek gehoor kunnen krijgen in de algemene autorisatieprocedure (weliswaar gevolgd door een politieke impasse). Dit leidt ook tot het ontstaan van kenniscoalities, waarin actoren samenwerken om eigen kennis en feiten te vergaren vanuit één bepaalde wetenschappelijke probleemstelling. Ten tweede is de defensieve toon in het debat het resultaat van de externe, absolute houding ten opzichte van technologie, die ggo-gewassen ziet als iets externs aan de menselijke sfeer waardoor ze alleen 'te nemen of te laten' zijn – een gepolariseerde Ja/Neen- vraagstelling.

Hoe kunnen we vooruit?

Deze analyse suggereert vier sporen om vooruit te kunnen met de huidige ggo-impasse:

1. Het stellen van andersoortige vragen. Vragen die breder zijn dan de huidige Ja/Neen-vraagstellingen rond voornamelijk de aanvaardbaarheid of veiligheid van ggo-gewassen in de politieke ruimte. Bijvoorbeeld hoe ggo-gewassen vorm geven aan onze manier van (samen)leven en onze landbouw, welk boer-landbouw wereldbeeld ze mediëren, … en als deze sociale, economische of culturele veranderingen, bijvoorbeeld, gewenst en nodig zijn.
2. Het scheppen van ruimte voor niet-wetenschappelijke argumenten binnen de algemene autorisatieprocedure van ggo-gewassen in de EU (en niet post-autorisatie zoals met het recente Amendement rond cultivatie). Dit kan onder andere door de algemene 'A + B' probleemdefinitie (veiligheid en keuzevrijheid) als basis om ggo-gewassen te autoriseren deels of geheel opnieuw in vraag te stellen.
3. Het anders benaderen van technologie, meer bepaald vanuit het geheel van gebruikerspraktijken rond technologie en met aandacht voor de bemiddelende rol van technologie, eerder dan vanuit een externe visie op technologie (die ofwel instrumenteel, ofwel deterministisch is).
4. Het in vraag stellen van de rol van wetenschap in het definiëren van politieke probleemstellingen rond nieuwe (landbouw)technologieën. Wetenschap kan namelijk niet elk probleem op eenzelfde manier structureren. De feiten die de wetenschap aandraagt zijn bovendien het resultaat van een specifieke wetenschappelijke vraagstelling. Niet alleen erkenning van de wetenschappelijke antwoorden in het politiek beslissingsproces, maar ook van de wetenschappelijke vragen, is hierbij essentieel.

SCIENTIFIC CURRICULUM VITAE

Linde Inghelbrecht (°1986) obtained a Master Degree in Biochemistry and Biotechnology at Ghent University magna cum laude. After graduation, she obtained a pre-doctoral FWO fellowship, to work as a PhD candidate at the Department of Agricultural Economics (Ghent University) in collaboration with the Social Sciences Unit of the Institute for Agricultural and Fisheries Research (ILVO). Her research area is systems innovation, (tackling) wicked problems and the field of technology design. Her case-study involves the impasse of genetically modified crop applications within EU agriculture. In this work, she analyses the systemic and socially (re)produced nature of this problem.

Peer reviewed scientific articles indexed in Web of Science:

Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2014). The non-GM crop regime in the EU: how do industries deal with this wicked problem?. NJAS-Wageningen Journal of Life Sciences, 70, 103-112.

Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2015). Explaining the present GM business strategy on the EU food market: the gatekeepers' perspective. New Biotechnology, 32(1), 65-78.

Peer reviewed scientific articles not indexed in Web of Science:

Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2014). The 'wickedness' of GM crop applications in the European Union. International Journal of Agricultural Management, 3(2), 67-69.

Presentations and posters at national and international conferences

Inghelbrecht, L. (2012). Attitude of the EU food industry towards ingredients derived from GM and non-GM IP crops. In: Workshop on Market for non-Genetically Modified Identity Preserved Crops and Derived Products organized by the European Commission Joint Research Centre, 21-22 June, Seville, Spain.

Inghelbrecht, L., Dessein, J., & Van Huylenbroeck, G. (2013). To commercialize or not to commercialize genetically modified crops in the EU environment. In: 19th International Farm Management Congress. Transforming agriculture: Between policy, science and the consumer, 21-26 July, Warsaw, Poland.

Inghelbrecht, L., (2013). Companies' policies on (not) commercializing genetically modified crop (applications) in the EU: a cross-industry analysis. In: Advances in Business-Related Scientific Research Conference, 20-22 March, Venice, Italy.

Inghelbrecht, L., (2013). GM crop commercialization in the EU market. How do agribusiness stakeholders decide? In: Knowledge for Growth Conference, 26 May, Gent, Belgium.

Inghelbrecht, L., (2014). GM crop applications in the EU context: Need for (new) theory and practice to govern this wicked problem. In: Theories of Sustainable Transition, 26-28 May, Copenhagen, Denmark.

Inghelbrecht, L., (2014). Wicked problem technologies: The need for new practice and theory to govern them. In: 5th International Sustainability Transitions Conference, 27-29 August, Utrecht, The Netherlands.

Research Reports, conference abstracts

Inghelbrecht, L. and Vandercammen M. (2011). Consumentenenquete mbt 'Perceptie van GGOs' (in Dutch). Online publication OIVO-CRIOC. Available at: http://www.oivo-crioc.org/files/nl/6070nl.pdf (accessed April 2016).

Inghelbrecht, L., (2012). Attitude of the EU food industry towards ingredients derived from GM and non-GM IP crops. JRC Scientific and Policy Reports, proceedings of a workshop on "Market for non-Genetically Modified Identity Preserved crops and derived products". Available at: http://ftp.jrc.es/EURdoc/JRC76117.pdf (accessed April 2016).

Inghelbrecht, L., Dessein, J. and Van Huylenbroeck, G. (2013). To commercialize or not to commercialize genetically modified crops in the EU environment. International Farm Management Congress Workshop proceedings, 169-173. Available at: http://www.ifmaonline.org/pages/congress.php (accessed April 2016).