Decision-Making and Risk Responsibility Related to the Use of Food Biotechnology

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Doctoral thesis
Swedish University of Agricultural Sciences
Uppsala 2017

Acta Universitatis agriculturae Sueciae
2017:83

ISSN 1652-6880

ISBN (print version) 978-91-7760-056-5

ISBN (electronic version) 978-91-7760-057-2

Print: SLU Service/Repro, Uppsala 2017

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This thesis contributes to knowledge about consumer decision-making and risk perception related to the use of biotechnology in food production. Paper I presents a meta-analysis that examined the systematic evidence from existing research on consumers' evaluation of biotechnology in food products. The results indicated that genetically modified (GM) food with agronomic benefits is considered an inferior alternative to unmodified food products, but its direct consumer benefits were considered more desirable. Furthermore, consumer evaluation of biotechnology was largely insensitive to the type of food product. However, the type of gene modification was important for consumers' evaluation. Using artefactual field experiments, Papers II-IV explore the effect of context on Swedish consumer behaviour in relation to a GM food with direct tangible benefits. Papers II and III examine the interdependency in consumer decision-making, with the focus of Paper III shifting towards satisfaction as the outcome of the decision-making process. Paper II shows that the policy regulations in place had a decisive influence on consumer acceptance and that the policy context itself may induce opposition to GM food. The greatest consumer opposition was found in the most restrictive policy scenarios. The aim of Paper III was to extend the Kano model of satisfaction and use it to assess consumer satisfaction in relation to decisions taken by upstream actors in the food value chain (FVC) with respect to GM food. The findings suggest that both consumer choices and satisfaction were dependent on the degree of unanimous stances adopted by upstream food value chain actors in supporting the GM food product. Actors' consistent rejection of GM food resulted in lower consumer acceptance of GM food and greater overall satisfaction. In contrast, consumers were more receptive to and satisfied with GM foods when the FVC actors consistently took supportive stances. This suggests that being pro-GM food is probably not a stable trait. In addition, the analysis lent support to a general preference for and higher satisfaction under a mandatory labelling regime. Paper IV explores the role of food policy regulations in cognitive information processing and deliberation of consumers' own risk responsibility related to GM food, and whether the effect is dependent on the type of risk. The findings suggest that consumers who have health concerns show less willingness to assign responsibility to themselves in situations where GM products are introduced.

Keywords: Decision-making, food choice, biotechnology, GMO, context effect, policy, consumer behaviour, satisfaction, risk perception, risk responsibility

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Dedication

To my parents and my son, Artin

Contents

List of publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

Hess*, S., Lagerkvist, C.J., Redekop, W., and Pakseresht, A. (2016). Consumers' evaluation of biotechnologically modified food products: new evidence from a meta-survey. *European Review of Agricultural Economics*, 43 (5), pp. 703-736.

Pakseresht*, A., McFadden, B.R., Lagerkvist, C.J. (2017). Consumer acceptance of food biotechnology based on policy context and upstream acceptance: Evidence from an artefactual field experiment. *European Review of Agricultural Economics*. (In press).

Pakseresht*, A. and Lagerkvist, C.J., (2017). Composite-level analysis of consumer satisfaction data from the Kano model: An application to consumer decision-making related to food biotechnology. (Submitted to *Food Quality and Preferences*).

Pakseresht*, A, Lagerkvist, C.J. (2017). Consumers' Risk Responsibility of Genetically Modified Food: Effect of Regulatory Context and Risk Dimensions on Cognitive information processing. (Submitted to *Food Policy*).

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Abbreviations

AFE	Artefactual Field Experiment
Bt	Bacillus thuringiensis
CETA	Canada-EU Free Trade Agreement
EFSA	European Food Safety Authority
EU	European
FVC	Food Value Chain
GM	Genetically Modified
GMO	Genetically Modified Organism
ISAAA	International Service for the Acquisition of Agri-biotech Applications
PA	Policy Arrangements
PR	Perceived Risk
R&D	Research and Development
RR	Risk Responsibility
SC	Self-Control
TAM	Technology Acceptance Model
TFQM	Total Food Quality Model
TPB	Theory of Planned Behaviour
TTIP	Transatlantic Trade and Investment Partnership
WTO	World Trade Organization

1 Introduction

1.1 Current status of GMO

The commercialisation of genetically modified (GM) crops is increasing rapidly, with these crops covering a total area of 181.5 million hectares across 28 countries in 2016. This is approximately 13 % of the world's total arable land (FAO, 2015). Between 1996 and 2016, the total acreage of worldwide cultivated GM crops had soared by a factor of ~110 from 1.7 million hectares to 185.1 million hectares (James, 2016). The global market value of harvested commercial biotech crops in 2016 was estimated to be around US$ 15.8 billion and contributing 35 % of the world's US$ 45 billion commercial seed market. According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA) (James, 2016), soybean, cotton, maize and canola are the most planted biotech crops, representing 78 %, 64 %, 26 % and 24 % respectively of their total global production in 2016 (Fig. 1).

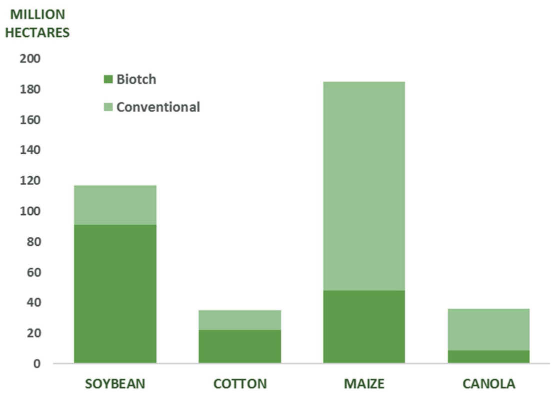

Figure 1. Global adoption rates (%) for the top four biotech crops (millions of hectares). Reprinted from ISAA (James, 2016)

Aside from these crops, the following GM crops have also been planted in different regions: sugar beet, squash, papaya, eggplant and alfalfa. It is estimated that this trend will continue in the coming years, including the commercialisation of new biotech crops such as rice and potato (James, 2016).

Despite this rapid global expansion in biotechnology, European countries are still cautious in applying biotechnology to the food production chain. The commercial planting of GM crops first started in the USA in 1995 with Bt corn[1] and Roundup Ready soybean. Over 50 GM crops have been field tested around the world in the last two decades (James & Krattiger, 1996), while within the EU only a few crops (including Bt corn and Roundup Ready soybean) have been released for commercialisation (Kärenlampi, 2000). In April 2015, however, the European Commission adopted authorisations for 19 genetically modified plants, including ten new authorisations for food/feed use, seven renewals of existing approvals and the importation of the two GM carnations[2].

At present in Sweden, GM crops are not grown for commercial use and no GM-derived animal feed is used. However, between 2010 and 2012 a GM potato (Amflora) with a modified starch composition (amylopectin), which is useful for industrial applications (used to make stronger yarn, adhesive cement and glossier papers), was approved and subsequently cultivated on a small scale in Sweden. Nevertheless, Amflora cultivation was stopped due to the hostile political climate towards GM crops in Europe and hence the company that produced GM potato seeds relocated its offices from Germany to the US.

1.2 Public policies on agri-biotechnology

1.2.1 The EU's legislative framework on GM food

In the few last decades, the application of biotech in food production has been one of the most contentious political issues in European countries. According to the European Regulatory System, each individual GM ingredient used in food

1. A GM crop developed "*using naturally-occurring bacteria found in the soil known as Bacillus thuringiensis (Bt)*" (Bawa & Anilakumar, 2013, p. 1036).
2. European Commission authorises 17 GMOs for food/feed uses and 2 GM carnations, published in Brussels, 24 April 2015. Accessed 22 May 2017, Available at: http://europa.eu/rapid/press-release_IP-15-4843_en.htm

and feed must be approved before entering the market. The EU authorisation and decision-making process is subject to extensive, case-by-case and science-based food evaluation (Davison, 2010).

Presently, approval of GM food in the EU is regulated by the European Food Safety Authority (EFSA) and the European Commission (EC) (Davison, 2010). At EU level, the present legal regime regulating various aspects of GMOs include Directive 2001/18/EC[3] on the deliberate release into the environment of genetically modified organisms, Commission Decision 2002/623/EC[4] regarding indirect (and long-term) effects or even potential threats based on the precautionary principle, and Regulation No. 1829/2003[5] on genetically modified food and feed (GM foods as well as processed foods derived from it). Furthermore, Regulation No. 2003/1830/EC[6] governs the traceability and labelling of food and feed products produced from GMOs. Based on these regulations any food/feed (regardless of whether it contains detectable modified DNA or protein) that is produced from, derived from or contains GMOs should be labelled (Rigby, Burton, & Young, 2006).

The EC provides co-existence guidelines for member states to avoid the unintended existence of GMOs in conventional and organic crops. Co-existence is measured by 'isolation distance', which refers to the minimum remoteness required between GM and non-GM crops to ensure that GM crops lose their pollination power before reaching non-GM cultivation (also known as a buffer zone). The co-existence guidelines are not binding and allow member states to institute their own protocols. For example, the buffer zone regulation in Sweden is 15 metres, whereas in Luxembourg it is 800 metres (Davison, 2010).

A labelling regulation increases traceability and responds to the concerns of consumers (including farmers buying feed), enabling them to make informed

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3. European Commission (2001), The European Parliament and the council of the European Union (12 March 2001). Directive on the release of genetically modified organisms (GMOs) Directive 2001/18/EC ANNEX I A. Official Journal of the European Communities. Page 17.
4. 2002/623/EC: Commission Decision of 24 July 2002 establishing guidance notes supplementing Annex II to Directive 2001/18/EC of the European Parliament and of the Council on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC (notified under document number C (2002) 2715).
5. Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed, [2003] OJL268/1.
6. Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC, [2003] OJL268/24.

choices between GM and non-GM food. However, the implementation of mandatory labelling carries costs that are regularly passed on to consumers (Marchant, Cardineau, & Redick, 2010). Marchant et al. (2010) examined the effects of the cost of mandatory labels on consumer choice and found that when the estimated cost of labelling is included, consumers significantly reject mandatory labelling.

1.2.2 Evolution of policies on GM food

The European Union has established a legal framework to ensure that the safe development of agro-biotechnology takes place in harmless conditions. However, policies governing GM food have evolved in recent decades and it is subject to further changes as the technology evolves. Figure 2 summarises the major events in the history of agro-biotechnology regulations.

EU member states experienced a *de facto* moratorium on approvals of genetically modified crops and foods between 1998 and 2004 (Buiatti, Christou, & Pastore, 2012). During the moratorium, the EU banned the commercial (and even experimental) growth of new GM crops or imports of new GM-based food products. However, since the introduction of GM crops the European Commission has been under pressure to allow cultivation and consumption of GM food and feed. Part of this movement was due to pressure applied by the World Trade Organization (WTO) and major GM producer countries on the EC to open its gates to GM crops (Stewart, 2009). Particularly, since 2006, the WTO regards the banning of GM crops as tantamount to an unlawful trade barrier (Rosenthal, 2007). Therefore, in September 2013 the General Court of the EU decided to reconsider a pending authorisation proposal for the marketing of maize 1507, which was considered the end of the moratorium[7].

Recently, the European Commission has approved new rules (Directive (EU) 2015/412) with the provision for member states to 'opt out' of the Europe-wide approval system for food derived from biotechnology, thus relaxing the restriction in order to protect specific national objectives. The proposal allows member states to restrict or prohibit the use of EU-authorised GM crops for food or feed purposes in their respective territories and localities. The new Directive 2015/412 permits derogation from the established EU-wide approval system and

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7. The Library of Congress, Restrictions on Genetically Modified Organisms: European Union, Accessed on 19 July 2017, Available at https://www.loc.gov/law/help/restrictions-on-gmos/eu.php

grants individual states the possibility of banning the cultivation of GM crops but not their import.

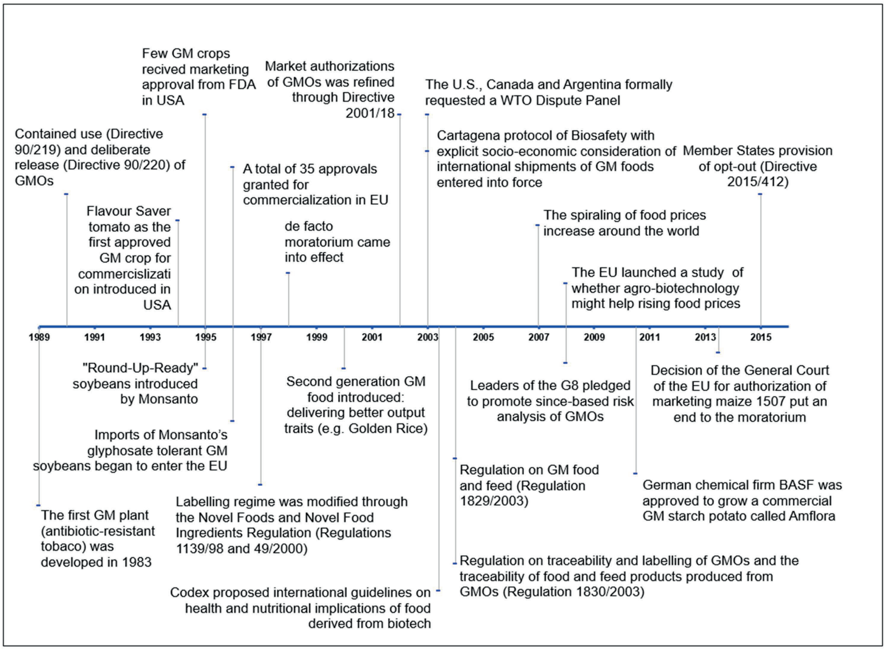

Figure 2. Landmark events in the history of agro-biotechnology regulations (Bawa & Anilakumar, 2013; Buiatti et al., 2012; James, 2011; James & Krattiger, 1996; Stewart, 2009)

Nevertheless national and international lobbies and policy dynamics went on to affect the EU's food policy towards agro-biotechnology (for details refer to Dobbs, 2010; Randour, Janssens, & Delreux, 2014). For instance, since 2007, concerns about an upsurge in food prices, flawed trade policies and global food insecurities have fostered greater receptivity to agro-biotechnology and resulted in the relaxation of EU opposition to the import of GM crops (Stewart, 2009). Restrictive GM regulations at EU level are recognised as one of the most important and controversial barriers to international and, more specifically, transatlantic trade (Stewart, 2009). The European Union's member states are under intense pressure to allow GM food imports from US and Canada (Dobbs, 2010; Harvey, 2014). Trade agreements and lobbying pressures such as the Transatlantic Trade and Investment Partnership (TTIP) and the Canada-EU Free Trade Agreement (CETA) would undermine the EU's restrictive policy towards GM food (Dobbs, 2010). Arts and Tatenhove (2004) argue that stabilisation of a policy is provisional since the arrangements are exposed to the pressure of continual change and hence policy arrangements may evolve in the course of history.

Furthermore, at a national level, different actors in the food chain may hold different positions that influence the regulation process. The relationships between different actors in terms of their cohesion and structural equivalence (the similarity of their profiles) is analysed through a "policy network" approach aimed at understanding the policy-making process (Börzel, 1998). Based on the policy network approach (Sabatier, 1987), a number of interdependent societal actors can be identified with different risk-benefit judgment capacities in relation to the context of GM food. The policy network refers to "*a cluster of actors, each of which has an interest, or 'stake' in a given…policy sector and the capacity to help determine policy success or failure*" (Peterson & Bomberg, 1999, p. 8). Focusing on the kind of social relationships between actors in the GM food value chain (FVC), the primary set of such actors includes the authorities (policy makers), farmers, food processing companies, retailers and consumers.

Partially adopting the policy arrangements (PA) conceptualised by Arts and Tatenhove (2004), it is possible to infer the perspectives on agro-biotechnology of different actors given the conceivable policy options. PA offers a framework for analysing change and stability in policy domain. The PA framework considers both institutional (i.e. involved actors and the interactions between them) and discursive (i.e. values, norms and opinions of involved actors) aspects of policy shifts (Wiering & Arts, 2006). The concept of PA is operationalised through four interrelated dimensions: *actors* (and coalitions between them) who operate in a specific policy domain, the *distribution of resources and power* (and the ability of actors to mobilise resources) between actors and its policy consequences, *rules of the game* which are forms of formal and informal interactions between actors in pursuit of decision-making, and *discourse* which refers to dominant interpretation schemes transformed into a particular set of practices in which the policy domain becomes meaningful (Arts & Tatenhove, 2004; Hunka et al., 2013).

According to Arts and Tatenhove (2004), some actors and coalitions might support the dominant policy discourse or rules of the game, while others might challenge it. Their power reflects the actors' influence in the various stages of the policy process and also implies the distribution of resources (such as financial means, knowledge, access to the media etc.) among the actors (Zouwen & Top, 2000). The dominant rules connote how a policy is enforced and the norms guiding it. Literature often distinguishes between two types of rules: formal rules reflecting the guidelines lawfully agreed by the actors, and informal rules referring to the dominant political culture and values (Zouwen & Top, 2000).

Driven by the policy network approach (Sabatier, 1987), the strategic conduct of a set of actors can be assumed, which may or may not comply with the rules of the game.

1.3 GM Food: benefits and concerns

Agri-biotechnology holds the promise of helping to improve food security through better protection from pests and drought, as well as increasing the nutrient content of foods (Adam, 1998). There is also support for the view that GM technology has significantly increased the global production of staple foods including maize, canola, and soybeans (Brookes & Barfoot, 2013).

Furthermore, several studies have reported the agronomic and economic advantages of GM crops in terms of higher yields and cost savings in agricultural production (*e.g.* Barrows, Sexton, & Zilberman, 2014; Huang, Hu, Rozelle, & Pray, 2008; Kalaitzandonakes, 2003; Phipps & Park, 2002; Qaim & Zilberman, 2003). A number of meta-analyses (Areal, Riesgo, & RodrÍGuez-Cerezo, 2012; Carpenter, 2010; Finger et al., 2011; Klümper & Qaim, 2014) have confirmed that farmers have benefited from the adoption of GM crops in different parts of the world. A meta-analysis by Klümper and Qaim (2014) and the study by Qaim and Zilberman (2003) documented the major agronomic impacts and significant economic advantages of cultivating GM crops. A recent study conducted by Lusk, Tack, and Hendricks (2017) using data from 28,000 observations in 800 counties in the US between 1980 and 2015 has found that the use of GM corn varieties can lead to better output (after controlling for weather). However, their results did not show significant effects of increased resilience to heat or water stress. Lusk et al. (2017) add a caveat that developments in gene technology could improve stress resilience effects.

Proponents claim that GM technology has the capacity to make changes to the farming system and ultimately deliver important environmental benefits (Brookes & Barfoot, 2013). Phipps and Park (2002) reviewed a number of studies and deduced that GM technology has the potential to markedly reduce overall pesticide use, although its effect (the size of the reduction) varies between different GM crop varieties.

Nevertheless, agricultural biotechnology continues to be a topic of public debate and the cause of controversies (see Table 1) revolving around a combination of concerns to do with environmental issues, human health, social inequalities and ethical values (Stirling & Mayer, 1999). In the view of supporters of agro-biotechnology, the concerns about commercialisation of GM crops has led to a complex and costly regulatory system in Europe (Paarlberg, 2002). Advocates of this view argue that difficulties in the European decision-making process for approving GM crops would hinder the investments and developments in applications of biotechnology in food production. Therefore, the risk of not adopting this technology should also not be underestimated (Zhang, Wohlhueter, & Zhang, 2016).

1.3.1 Environmental risks

Critics point to a handful of environmental risks such as biodiversity loss, gene escape, chemical use and unexpected effects that the introduction of GM crops on a large scale may induce (Losey, Rayor, & Carter, 1999; Pimentel, 2000; WHO, 2014). Adam (1998) argues that environmental hazards are unavoidably tied to the successes of industrial developments, including gene technology. Despite the fact that all GM crops should pass legislation assessments before being released to the environment, it is contended that the ultimate effect of some GM crops (*e.g.* herbicide-resistant crops) on agricultural practices is difficult to evaluate from field trials (Adam, 1998; Peterson et al., 2000). There is also a belief that the costs of testing and monitoring the effects of GM crops increase as the size of area increases, and their impacts become less predictable (Peterson et al., 2000). There is also a view on agri-biotechnology development that the release of genetically modified organisms into the environment has the potential to both degrade and enhance the functioning of agroecosystems, depending on the type of GM crop and how it is used (*e.g.* Conway, 2000; Pimentel, 2000). According to this view, the introduction of GM crops could lead to either an increase or reduction in pesticide use, the loss or conservation of biological diversity, or the improvement or degradation of ecological functions. For instance it is stated that GM pesticide-resistant crops protect plants against unwanted insects, but there is a risk that these modified traits can also have unintentional effects on other species (Losey et al., 1999). Furthermore, there is substantial concern about the possibility of passing the new traits from GM cultivars on to wild relatives (or other plants), which could change the ecological role of wild relatives and potentially lead to them out-competing other species (Pimentel et al., 1989; Quist & Chapela, 2001; Regal, 1993; Smits & Zaboroski, 2001).

1.3.2 Health risks

Health concerns are an important risk dimension associated with GM food (Martinez-Poveda, Molla-Bauza, del Campo Gomis, & Martinez, 2009). Some scholars point to concerns around the unpredictable nature of biological developments and the risk of inducing toxic, allergenic compounds through genetically modified crops (Gupta, 2004; Martinez-Poveda et al., 2009; Miles, Ueland, & Frewer, 2005; Schubert, 2002; Smits & Zaboroski, 2001). One of the other controversial concerns of agro-biotechnology has been linked to the stable introduction of the genetic material of foreign organisms (*e.g.* bacterium) into food rather than engineering the crop's genetic contents *per se* (Myskja, 2006; Verhoog, 2003; Wolfenbarger & Phifer, 2000). Contaminant residues from genetically modified organisms are another safety issue that been a source of consumer anxiety regarding food derived from biotechnology (Knowles, Moody, & McEachern, 2007). In comparison with hygiene standards and food poisoning, contaminant-based 'food scares' (antibiotics, hormones and pesticide incidents) appear to be of more concern to consumers (Huang, 1993; Miles et al., 2004). Uncertainty and a lack of knowledge of the long-term health effects of such technologies is another concern for groups of consumers (Grunert, 2005).

Nevertheless, existing objective risk assessments have failed to identify risks and concluded that GM foods are safe for human consumption and carry no additional environmental risks compared with their conventional counterparts (see DeFrancesco, 2013; European Academies Science Advisory Council, 2013; European Commission, 2010). In one of these studies, Snell et al. (2012) scrutinised 24 longitudinal studies on the effects on animal health of diets containing different GM feed (including maize, potato, soybean, rice and triticale). The results do not suggest any biological or toxicological health hazards (Snell et al., 2012). More recently, Zhang, Wohlhueter, et al. (2016) conducted a critical review of the promises and concerns around agro-biotechnology and found that most of the above health risks are speculative, but nevertheless plausible and demand ongoing scientific scrutiny. The authors maintain that the advantages are too tangible to be ignored in a trade-off with unknown and unintended disadvantages (Zhang, Wohlhueter, et al., 2016, p. 122).

1.3.3 Socioeconomic risks

It is argued that the net economic and technological impacts of adoption of genetically modified crops might be overestimated (Qaim, 2009). For instance, Conway (2000) questioned the role of biotechnology as a technical innovation for improving agricultural productivity. The methodological approach and inference of some of studies showing large agronomic and economic advantages are criticised (e.g. Glover, 2010; Stone, 2012). Peterson et al. (2000) argue for a more comprehensive assessment of GM crops to include comparisons to alternative agricultural practices and associated costs and benefits. Peterson et al. (2000) also point out that it is a challenge to determine what level of potential risk is acceptable for a given benefit because while the direct benefits tend to be directed at a small section of the population, the risks of agro-biotechnology are scattered widely across society at large.

Furthermore, opponents have noted potential problems of monopolisation due to intellectual property rights (Stewart, 2009). More specifically, there is a concern that small-scale farmers are negatively impacted by the market dominance of a few powerful seed companies (Barrows et al., 2014). It is stated that GM technology will lead to greater economies of scale in the agricultural sector and intensification in the food supply chain with its concentration in the hands of a small group of large-scale producers (Drummond & Marsden, 1999; Marsden, Flynn, & Harrison, 2000). Consequently, agricultural and rural structural changes are a cause of inequality (Gupta, 2004; Peterson et al., 2000). Likewise, biotechnology's ability to eliminate social inequality and welfare, especially in the developing world, has been criticised (Gupta, 2004; Peterson et al., 2000). The proprietary nature of biotechnology hinders GM research, and patent protection may work as a trade barrier to the entry of GM foods in developing countries (as has been the case with pharmaceuticals) and increase the economic gap between the developing and developed worlds (Gupta, 2004; Peterson et al., 2000; Stewart, 2009).

1.3.4 Ethical risks

Consumer surveys have reported ethical concerns associated with gene technology among the general public (Eurobarometer, 2010; Myskja, 2006), with respondents saying that GM technology 'tampers with nature' and hence is morally questionable (Miles & Frewer, 2001; Myskja, 2006; Stirling & Mayer, 1999). Moreover, some groups of consumers consider the development of food from biotechnology to be in conflict with their religious values (Stirling & Mayer, 1999; Straughan, 1999).

Table 1. *Risk and benefit dimensions associated with developments in agricultural biotechnology*

Dimensions	Potential benefits	Risks and concerns
Human health and safety	• Agricultural biotechnology (even some of the first-generation GM crops) deliver some health benefits (Barrows et al., 2014) • GM food enhances human nutrition (Kishore & Shewmaker, 1999) • Extremely low health risks of GM food (Bennett, Phipps, Strange, & Grey, 2004; European Food Safety Authority, 2004) • Agricultural biotechnology lowers pollution emissions (due to less chemicals) from production and hence lowers nitrification and water acidification (Bennett et al., 2004)	• There is concern about possible toxicity in GM food (Knowles et al., 2007) • Critics assert that GM food may induce allergenicity (Stirling & Mayer, 1999). There are some concerns about unknown risks (Miles & Frewer, 2001; Schubert, 2002) • Genes transfer from the product to human's genome content (Myskja, 2006; Verhoog, 2003; Wolfenbarger & Phifer, 2000)
Environmental issues	• Risk of resistance build-up like other pest control methods (Barrows et al., 2014) • No evidence of environmental risks related to the GM food and crops currently authorised (Paarlberg 2010) • Reduced pesticide use and increased net environmental benefit (Phipps & Park, 2002; Qaim, 2009; Shelton et al., 2013). • There is evidence of the reintroduction of seed varieties and enhancement of biodiversity (Bennett, Chi-Ham, Barrows, Sexton, & Zilberman, 2013; Zilberman, Ameden, & Qaim, 2007) • Improved farming practices including reduced tillage operations (Barrows et al., 2014).	• Adopting GM crops may increase resistance build-up (Pimentel et al., 1989) • Non-target species may be affected (Losey et al., 1999) • Agricultural biotechnology leads to increased use of chemicals (Conway, 2000; Pimentel, 2000) • There are some uncertainties regarding long-term environmental effects (Bredahl, 1999; Grunert, 2005; Wibeck, 2002) • Agricultural biotechnology will lead to biodiversity loss (Conway, 2000; Pimentel, 2000) • Opponents argue that there is a possibility of gene drift (Stirling & Mayer, 1999)

Dimensions	Potential benefits	Risks and concerns
Socio-economic concerns	• Direct benefits (mostly cost reductions to the farmer and yield increase) and the facilitation of changes in farming systems (Brookes & Barfoot, 2013) • Adoption of GM seeds lowered prices (Barrows, Sexton, & Zilberman, 2013) • Increased area of cultivation (Lichtenberg & Zilberman, 1986) • Most of the benefits distributed to farmers and consumers and less to seed producers (National Research Council, 2010) • Increased yields (Qaim & Zilberman, 2003) • Farm cost reduction (National Research Council, 2010; Piggott & Marra, 2008)	• Literature has addressed issues regarding intellectual property rights (Stirling & Mayer, 1999) • Affects farmers' rights (Conway, 2000; Qaim, 2009) • Adopting GM seeds on a large scale will increase the chances of constructing monopolies (Frewer et al., 2004) • Reduced freedom of choice (Wibeck, 2002) • There is a public welfare debate on the use of GM technology (Peterson et al., 2000)
Ethical concerns	• Gene technology contributes to increasing world food production, Literature points to the advancement in gene technology and conflicts with religious values (Bauer, Durant, & Gaskell, 1998; Stirling & Mayer, 1999)	• It has been noted that GM development is 'tampering with God's plan' (Straughan, 1999) • Critics consider agricultural biotechnology as an unnatural process (Siegrist, 2008; Straughan, 1999; Wibeck, 2002). Reduces hunger through increased crop yields and food quality (Barrows et al., 2014).

1.4 Perspectives on subjective risks

In this section, a broader introduction to the concepts and perception of risk is provided. First, definitions of risk from different perspectives are presented with conclusions regarding the risks associated with GM food. Then, various theoretical approaches on risk assessment are introduced and the distinction between subjective risk and objective risk reviewed.

1.4.1 Conceptualisations of risk in relation to GM food

The term 'risk' when applied to food biotechnology has been used widely by different scholars, yet an unequivocal definition of risk does not exist. Hansson (2005, p. 68) distinguishes between four different versatile applications and meanings of the word 'risk'. Risk may be used to mean an unwanted event (e.g. danger of cancer for smokers), the cause of an unwanted event (e.g. smoking as a health risk), a synonym for the probability of an unwanted event (e.g. the likelihood of power failure) or the statistically expected value of unwanted events (i.e. probability-weighted value) which may or may not occur. Renn (1998, p. 51) defines risk as "*the possibility that human actions or events lead to consequences that affect aspects of what humans value*". The concept of risk signifies the probability that an "*undesirable state of reality (adverse effects)*" may happen as a consequence of human actions (or events) or natural incidents (Renn, 1998, p. 51). Hence, the concept of risk comprises three elements: undesirable outcomes, the possibility of occurrence and the link between the two (Renn, 1992a, p. 55; 1998, p. 51; Vlek, 1996, p. 10).

Luhmann (2005, pp. 21-22) contrasts the concept of risk with danger, defining risk as the uncertainty in connection with future loss attributable to a decision, while the danger is not attributable to a decision. Connected with the risk society of Ulrich Beck (1992), Evers and Nowotny (1987, p. 34 cited in Voss, 2005, p. 5) assert that "*one is affected by dangers, not by risks; dangers are quasi assigned civilizingly (...)*", whereas risks are individually appraised and deliberately taken in awareness of possible losses and with the ambition to gain the desired outcome (Voss, 2005). An alternative view to the risk society thesis is the Foucault's (1991) governmentality approach where risk is acknowledged as a 'technology of government' (O'Malley, 2008), i.e. risks are not considered as "*intrinsically real, but as a particular way in which problems are viewed or 'imagined' and dealt with*" (O'Malley, 2008, p. 5).

Governmentality can be understood as the formation of attitude and belief in a population through institutions and the media. From the perspective of governmentality, the notion of risk can be understood as a concept produced entirely socially (not as a result of external forces) to shape and control people and to govern societies (Zinn, 2006).

Pauly (2007) states that risk is the absence of certainty when the consequences of a decision are not known beforehand. Therefore risk can be seen as uncertainty as a consequence of decision-making when there is a chance of adverse effects. In general, concepts of risk and uncertainty are used interchangeably. In economics, however, the concept of risk and uncertainty are separate. Knight (1964) distinguishes risk from uncertainty and argues that risk is present when future adverse events happen with quantifiable probability and uncertainty exists when the likelihood of future adverse events is unquantifiable. According to Epstein (1999, p. 579) "*risk refers to situations where the perceived likelihoods of events of interest can be represented by probabilities, whereas uncertainty refers to situations where the information available to the decision-maker is too imprecise to be summarized by a probability measure*". This dichotomy, referred to as the '*positivistic risk paradigm*' (Van Asselt, 2000), is still the dominant approach on risk. However an increasing number of scholars (see, for example Nowotny, Scott, Gibbons, & Scott, 2001; Renn & Walker, 2008; van Asselt & Vos, 2006; Vercelli, 1995) argue that the distinction between risk and uncertainty based on the measurability/immeasurability of probability cannot be made (especially for complex risks) as easily as the positivistic risk paradigm assumes (for detail discussion see Versluis, van Asselt, Fox, & Hommels, 2010). Hansson (2005) suggests that technology is associated both with quantifiable risks and non-quantifiable uncertainties, which may be rather challenging to get to grips with. van Asselt and Vos (2006) use the notion of 'uncertain risks' to refer to the "*uncertain situations, which may result in one or more effects that are valued negatively or considered unacceptable by at least one, but possibly more, societal actors*" (p. 3). The authors argue that the introduction of a new genetically modified substance is an example of uncertain risks where uncertainties regarding underlying processes and the complex multi-causal interactions between causes and effects may render it difficult, if not impossible, to determine what may occur (van Asselt & Vos, 2006, p. 3). In addition uncertainty often arises from complexity (Van Asselt, 2000), which also results in ambiguity (Van Asselt & Renn, 2011). In Renn and Walker's view, 'ambiguous risks' refer to situations in which "*value judgments [about risks] (...) differ from one individual to another*" (2008, pp. 34-40), which typically happens in multi-actor settings (Versluis et al., 2010). This means that there are different legitimate values and interpretations used by different actors to evaluate whether there could be adverse effects and whether these are acceptable (Van Asselt & Renn, 2011).

The concept of risk related to GM food can be regarded as a mixture of uncertain risks (van Asselt & Vos, 2006) and ambiguous risks (Renn & Walker, 2008), implying an uncertain situation that may result in adverse outcomes in which the value judgment of this unacceptable outcome may differ from one actor to the next (refer to discussion in page 438, Van Asselt & Renn, 2011).

1.4.2 Approaches to risk assessment

Since the mid-1980s, there has been an increase in academic and professional interest in the issue of risk associated with technology developments. Different approaches exist in relation to understanding risk and risk perceptions, each with their own conceptual basis. The extensive literature review undertaken by Renn (1992a, p. 57) distinguishes between seven approaches to the conception and assessment of risk (see Fig. 3), including actuarial, toxicological and epidemiological, engineering, economical, psychological, sociological and cultural. Renn (1992a, p. 55) systematically compares these approaches and identifies three common elements of undesirable outcomes, the possibility of occurrence and the link between the two.

The first three approaches (i.e. actuarial, all-hazards, and probabilistic) are called technical risk perspective (objective risk assessment). Technical approaches to risk extrapolate the negative impacts of a disaster by averaging these events over time and computing relative frequencies (observed or modelled) to determine probabilities (Renn, 1992a, p. 59). The first perspective in the technical approach is an actuarial one that has been adapted to risk analysis, applied primarily in insurance management. The actuarial method stands for translation of the relevant statistical material into risk appraisal (Sreenivasan, Kirkish, Garrick, Weinberger, & Phenix, 2000). The base unit is the expected value (harm) which is the relative frequency of a hazardous event over time (Renn, 1992a, p. 59). The all-hazards approach to risk analysis is similar to the actuarial analysis, except in the calculation of the likelihood of undesirable effects. The first step here is to identify hazards and then determine the risk to humans. The information provided under probabilistic risk analysis (engineering) is applied to predict the failure of complex technological systems (e.g. nuclear power plants) (Renn, 1992a, p. 59).

The concept of economic perspective is close to the technical perspective except that the notion of expected harm resulting from an event is shifted into subjective utility, i.e. the degree of (dis)satisfaction with the probable outcome (Renn, 1992a, p. 62). The economic approach enables individuals to compare options with a different risk-benefit portfolio according to overall satisfaction (see Derby & Keeney, 1981; Shrader-Frechette, 1984). Theoretically, every person attaches subjective probability (weights) of outcome or "*state of the world*". The expected utility function of two outcome states is a weighted average of the utilities of desired outcomes (positive utility) and adverse outcome (negative utility). Hence, the utilities derived from a risky prospect can be evaluated and compared with the utility of the *status quo ante* to decide the preferred choice (Renn, 1992a, p. 62). In fact, similar to the technical method, the economic approach assumes that people behave in a rational manner by weighing up information before making a decision. However, there are a number of cognitive biases associated with "subjective probability" that a decision maker assigns to undesired outcomes. For example, individuals often demonstrate difficulties in distinguishing between a near-zero probability and zero, which may result in undesired outcomes being ignored (Pauly, 2007). It is even more challenging to define and distinguish between negative consequences *per se* when it comes to choices with a high degree of uncertainty and ambiguity. In such cases, the decision-maker may attribute an additional amount of disutility to a certain option due to ambiguity in determining the likelihood or understanding of undesired consequences (Pauly, 2007). According to this view, individuals have exaggerated fears that information asymmetry may arise due to inadequate or incorrect information distribution, which inherently increases the risk. This assumption implies that additional information will lessen this exaggerated risk opinion (Douglas, 1986). However, other studies have rejected the belief that further information *per se* will modify perceptions (Freudenburg, 1993).

Research by cognitive psychologists shows that other considerations may also affect individuals' risk perceptions rather than merely estimating probabilistic information (Wickson, 2007). The focus of the psychological perspective is on personal preferences for probabilities and attempts to explain why individuals do not base their risk judgments on expected values. The psychology approach emerged through studies that were attempting to understand how people process information. The early work in this area indicated that individuals use short cuts (heuristics) in processing information which, in some cases, may lead to biases in decision-making (Gilovich, Griffin, & Kahneman, 2002). Subsequent published works build on cognitive biases on the role of affect, emotion and stigma on risk perception (Tversky & Kahneman, 1974). This approach, which became the psychometric paradigm developed by Slovic, Fischhoff, and Lichtenstein (1984), led to a 'cognitive map' of hazards. Psychometric paradigm assumes that characteristics such as dread, novelty and controllability are inherent attributes of risk that are responsible for influencing individual perceptions of risk (Boholm, 1998; Marris, Langford, Saunderson, & O'Riordan, 1997; Slovic, 1987).

One of the early works published by Starr (1969) adopted the revealed preference approach to understand what types of risks are considered acceptable by the public. Starr (1969) found that people tend to accept risks that are voluntary even if the risk magnitude is greater in comparison with involuntary risks. Another belief in cognitive psychology arises from the cognitive valence theory put forward by (Andersen, 1989). Based on the valence theory approach, two types of negative (such as dread and danger) and positive (such as happy and hopeful) emotions influence the perception of risk differently. The valence theory implies that pessimistic risk perceptions are attributed negative emotions, while positive emotions lead to a more optimistic view of risk (Lerner & Keltner, 2000). In fact, in contrast to technical experts, psychometric researchers suggest a contextual assessment of the risks posed by a particular technology rather than statistical considerations of likelihood and magnitude (Otway & Wynne, 1989; Slovic, 1987).

Psychometric studies have been criticised paying scant regard to social factors (Cutter, 1993, p. 20; Lupton, 2013, p. 23). Proponents of the sociological perspective claim that psychometric studies offer snapshots of risk judgments outside of their social contexts (Rogers, 1997, p. 745). Based on the sociological perspective, individuals' perception of risk is subjective to social discourses and a change in diverse social settings due to new knowledge and experiences obtained over time (Bellaby, 1990b; Irwin, Simmons, & Walker, 1999). In addition, it is claimed that dissimilar methodological approaches applied in the psychometric paradigm may yield different results in understanding how different groups perceive risk (Gustafsod, 1998; Wilkinson, 2001). Hence, the development of sociological and anthropological approaches to risk perception seeks ways of coping with these limitations (Wickson, 2007).

The two central theories of sociological risk research are risk society (Beck, 1992) and cultural theory (Douglas & Wildavsky, 1983). Risk society theory concerns how contemporary societies organise themselves in response to exposed risks. According to Beck (1992, p. 21) a risk society is *"a systematic way of dealing with hazards and insecurities induced and introduced by* *modernization itself*". Beck (1992) emphasises that the risks are socially constructed and some risks are perceived as more dangerous due to mass media coverage (known as risk consciousness). Furthermore, he points out that modern society (risk society) leads to the scrutiny of risks, inducing prejudgments. In contrast, Douglas's (1978) cultural theory suggests that risk perception is determined by people's prior pledges concerning different sorts of social solidarity (Wilkinson, 2001).

The cultural theory of risk explains why risks become politicised (Tansey & O'riordan, 1999). The term 'politicised' implies that it is a function of "*fairness considerations such as trust, liability distribution, and consent*" (Rayner, 1993, p. 198). According to (Wickson, 2007, p. 328) the key distinctive feature of cultural theory is "*the belief that commitment to a preferred form of social organization implies common values and will therefore lead to common fears*". Proponents of cultural theory of risk criticise the rational choice economic approach, arguing that it disregards the role of cultural structure (Douglas & Wildavsky, 1983). In essence, cultural theory advocates that risk perception is not essentially related to physical risk, but rather that the variances in risk assessments stem from the commitment to various social actors and beliefs about nature (Tansey & O'riordan, 1999). Researchers in cultural theory categorise people as individualists, hierarchists and egalitarians based on their responses to a political attitude questionnaire and correlate the public risk perceptions (Wilkinson, 2001). However, critics of the sociological perspective report that there has been a failure to find convincing results on the correlation between cultural biases and social perception of risk (Brenot, Bonnefous, & Marris, 1998, pp. 738-739; Renn, Burns, Kasperson, Kasperson, & Slovic, 1992, p. 139).

Renn (1992a, p. 54) outlines the positivistic view and social constructivist view of risk as two extremes in a spectrum of risk perspectives. In the positivistic view, risk is regarded as an objective entity of an event when the probability of well-defined adverse effects is known. Risk management in this view is to prioritise risk and assign resources to reduce the most risky effect first through objective measures of probability and magnitude of harm. However, in the social constructivist view, risk is regarded as a social or cultural construction where priorities in risk management are set by social values and lifestyle preferences. According to (Renn, 1992a), these two extremes are poor descriptions of reality and an appropriate theoretical framework to explain the social response to risk should lie somewhere between the two.

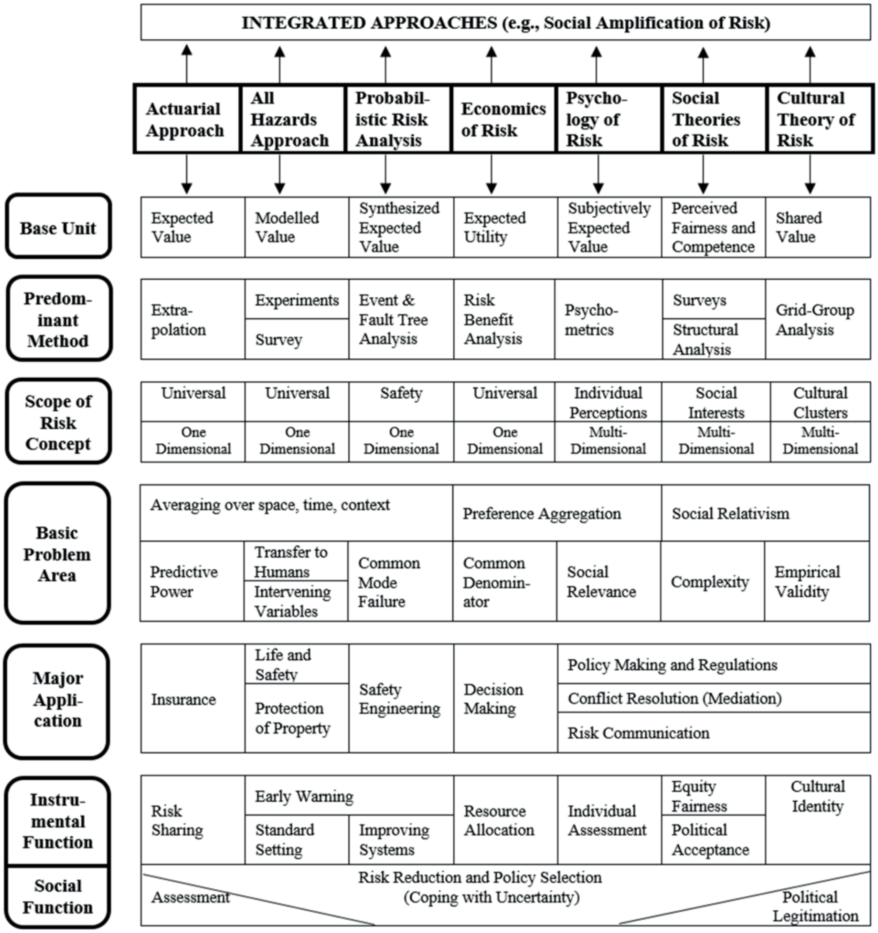

Figure 3. A systematic classification of risk perspective (Renn, 1992a, p. 57; Slovic, 1987)

1.4.3 Risk perception

Risk perception is defined as "*the process of mentally representing and assimilating the likelihood of adverse events that are connected with certain objects or activities and that might occur in the future*" (Renn & Swaton, 1984, p. 584). Risk perception in the context of food safety, for instance, is "*what the individual believes would be the amount of health risk, if any, they would face from consuming a food product*" (Schroeder, Tonsor, Pennings, & Mintert, 2007, p. 1). Slovic (1987) suggests two main dimensions of risk perception: dread and unknown risks. 'Dreaded risks' refer to those judged (subjectively) to be uncontrollable and involuntary and to affect a large group of people with potentially catastrophic consequences. 'Unknown risks' are unobservable, novel, uncertain and often have delayed effects. Perceptional factors influence risk perception (Kahneman & Tversky, 1979; Slovic, 2000; Slovic, Finucane, Peters, & MacGregor, 2004a; Tversky & Kahneman, 1974), based on the cross-links between the triple strand of conscious, subconscious and affective factors (Hillson & Murray-Webster, 2007).

Conscious factors are rational situational factors representing visible and quantifiable characteristics of the state, including familiarity (referring to previous experiences of being in the same situation), manageability (knowing how to cope with the situation), proximity (anticipating the timeframe in which the adverse outcome happens), propinquity (it matters to the individual or not), severity of impact (the degree of risk), and group dynamics and culture (norm behaviour shared by a group of people).

Subconscious factors comprise mental short cuts made to facilitate decision-making, known as heuristics, and other sources of behavioural cognitive biases. Heuristics provide mechanisms for rapid data filtering to decide the most important elements leading to decision-making, especially in complex or uncertain situations. Hillson and Murray-Webster (2007) categorise some important heuristics such as intuition (it feels right, I do not need more data (Sinclair & Ashkanasy, 2005)), representativeness (expecting a phenomenon to happen based on previous experience or stereotype (Kahneman & Tversky, 1972)), availability (the most recent data is more striking (Groome & Eysenck, 2016)), confirmation trap (collecting evidence to substantiate prior convictions and ignoring contrary data (Plous, 1993)), anchoring (first impression lasts

(Baron, 2000)), lure of choice (keeping options open (Bown, Read, & Summers, 2003)), affect (striving for pleasure and pain avoidance (Slovic, Finucane, Peters, & MacGregor, 2007)), and group effects (*e.g.* we all think like this (Reimer & Hoffrage, 2006)). However, since heuristics operate subconsciously, they may introduce significant bias into decisions (Hillson & Murray-Webster, 2007).

Cognitive biases include prospect theory (implying individuals make decisions based on the probable value of losses *versus* gains, rather than the ultimate outcome (Kahneman & Tversky, 1979)), repetition bias (undue importance assigned to recurrent data), illusion of control (overestimation of one's influence (Thompson, 1999)), illusion of knowledge (overconfidence that more information increases the accuracy of forecasts), intelligence trap (intelligent people do not accept criticism since they know they are intelligent (De Bono, 2006)), optimism bias (delusional optimism that a person is less at risk (Shepperd, Carroll, Grace, & Terry, 2002)), fatalism bias (positive focus on the impact of outcomes rather than on probabilities), precautionary principle (pessimistic focus on the impact of outcomes rather than probabilities) and hindsight bias (after the outcome of an unforeseeable event is revealed, a person believes he/she knew it all (Roese & Vohs, 2012)).

Affective factors are gut-level responses rooted in intuitive emotions or deep primary feelings rather than rational assessments (Hillson & Murray-Webster, 2007). Affective (emotional) factors include fear (of consequences), desire (of consequences), love (level of attraction), hate (level of dislike), joy (optimistic vision of the world), and sadness (pessimistic view of life) (Hillson & Murray-Webster, 2007, p. 8).

1.4.4 Risk assessment and risk acceptance

According to Renn (1998, p. 51), risk assessment is "*the scientific process of determining the components of risk in precise, usually quantitative terms*". The FAO/WHO document (World Health Organization, 1997, p. 5) describes a risk profile as the process of food safety risk assessment and its context, with the aim of identifying and prioritising those elements of the hazard or risk that are relevant to risk management decisions. A typical food risk profile may include "*a brief description of the situation, product or commodity involved; the values expected to be placed at risk e.g. human health, economic concerns; potential consequences; consumer perception of the risks; and the distribution of risks and benefits*" (World Health Organization, 1997, p. 5).

Risk acceptance denotes "*the results of balancing positive and negative consequences (utilities) and their probabilities by forming a general evaluative judgment of the riskiness of a certain object or activity*" (Renn & Swaton, 1984, p. 584). Consumer risk acceptance is central to the success of novel food technologies (Chen, Anders, & An, 2013; Siegrist, 2008) and this is affected by a number of psychological factors (Ram & Sheth, 1989).

1.5 Perspectives on risk responsibility

The notion of risk responsibility has been discussed within the GM food literature (e.g. Bickerstaff, Simmons, & Pidgeon, 2006; Mayer, Hill, Grove-White, & Wynne, 1996). However, despite the intimate connection between risk and responsibility (Kermisch, 2012; Lindell & Perry, 2000; Terpstra & Gutteling, 2008), the link between technology risks and responsibility is relatively unexplored (with some exceptions e.g. the works of Lenk, 2007; Lenk & Maring, 2001). In this section, the first definitions of risk responsibility are reviewed, then theoretical perspectives on risk responsibility are discussed and finally presenting empirical evidence on risk responsibility with respect to food choices.

1.5.1 Definition of risk responsibility

Modernity, development, technological advancements and associated risks and uncertainties have necessitated the discussion of risk responsibility in recent decades (Giddens, 1999). Various notions of risk responsibility can be found among scholars and lay people, often in an incoherent fashion (Schicktanz & Schweda, 2012). Responsibility is a relational and multi-layered term and its definitions and implications are sometimes unclear (Giddens, 1999; Schicktanz & Schweda, 2012).

Hart (2008, pp. 212-222) distinguishes between different types of responsibilities: role-responsibility, causal-responsibility, liability-responsibility and capacity-responsibility. Role-responsibility addresses a particular position to which specific duties are attached. For example a father who is a driver is responsible for not leaving his child alone in a car. Causal-responsibility refers to the cause of an incident, implicitly in a quasi-mechanical sense (Kermisch, 2012). For instance, the lack of oxygen is responsible for the death of a child that has been left alone in a car. Capacity-responsibility implies the capability of an actor to accomplish his or her duties. Capacity in this view refers to the understanding, reasoning and control of the actions (Kermisch, 2012, p. 93). In this view, the driver who has a heart attack is not responsible for the car accident. Liability-responsibility refers to the legal aspect of responsibility with a retrospective view that looks for the responsible person to be punished for an unwanted event. For instance, a driver is liable to pay compensation for the damage caused in a car accident if he or she was drinking and driving (Kermisch, 2012).

Ladd (1991) defines the concept of responsibility in a moral sense which is referred to as 'civic virtue' or, as Kermisch (2012, p. 93) puts it, virtue-responsibility. Virtue-responsibility is linked to 'moral deficiency' instead of fault in the conventional definition of responsibility (Ladd, 1991, pp. 85-89). Responsibility here refers to the lack of care or concern for the comfort and wellbeing of other stakeholders. For example, consider a case in which safety issues are not the priority of management. Although it is not the fault of management, their absence of care for others at risk is an expression of virtue-responsibility.

Also from a moral perspective and rooted in the responsibility dimensions of Hart (2008), Kermisch (2012, p. 93) considers blame to be referring to responsibility. This view implies that first there is a violation of a moral norm while the actor has capacity-responsibility (understanding and controlling the conduct) and then the actor is causally-responsible for the harmful outcomes of his or her behaviour.

Responsibility in a business context has been defined as referring to "*a sphere of duty or obligation assigned to a person by the nature of that person's position, function, or work*" (Barry, 1979). Hence in this definition, responsibility refers to decisions a person makes based on available choices depending on his or her own insights. Alternatively, an accountable actor is "*held to external oversight, regulation, and mechanisms of punishment aimed to externally motivate responsive adjustment in order to maintain adherence with appropriate moral standards of action*" (Bowie, 1982, pp. 95-96). Hence, accountability suggests that external praise or blame may affect a person's particular behaviours, while responsibility implies that agents can identify their choices and make their own decisions (Bivins, 2006). The difference between responsibility and accountability resides in autonomy and delegation. In fact, a person may delegate responsibility but remain accountable for the results. For instance, if a food producer delegates its health-related risk responsibilities to the regulatory system, the producer still can be blamed for the likely negative production consequences.

According to Schicktanz and Schweda (2012, p. 131), the general concept of responsibility requires at least three 'relata' (components): a subject, an object and an instance. Schicktanz and Schweda (2012) add more relata to the responsibility construct. The authors define the relationship between these entities as "*someone (subject) is in a particular time frame (time) retrospectively/prospectively (temporal direction) responsible for something/someone (object) against someone (norm-proofing instance) on the basis of certain normative standards (standard) with certain sanctions or rewards (consequences)*" (Schicktanz & Schweda, 2012, p. 133). Hence, they suggest that a theoretically infinite possible number of categories can be considered depending on the context of study. With regard to the category subject, all upstream actors in the GM food value chain (FVC) can be considered, including farmers, food processors, retailers and policymakers. Objects in this model denote any entity that, according to their moral status and underlying anthropologies, can be regarded as an object of responsibility (responsibility towards whom). In the context of biotechnology, it may refer to humans, animals, the environment or society as a whole (Warren, 2000). Temporal direction denotes responsibility orientation, implying either a retrospective (backward-oriented) or prospective (forward-oriented) perspective. The former deals with the legal sphere of responsibility, whereas the latter implies "*being in charge of future events*" (Schicktanz & Schweda, 2012, p. 133). In the context of GM food, retrospective is related to the legal aspect of agricultural biotechnology. This retrospective dimension is primarily discussed in the context of casual responsibility or liability discrepancy. The prospective responsibility is more important in the new technology contexts connected with a complex network of social roles and uncertainty inherent in the decision options and associated consequences. The category instance refers to the "*authority that decides whether a norm has been met or violated and thus the corresponding responsibility has been fulfilled or not*" (Schicktanz & Schweda, 2012, p. 134). Theoretically, different authorities can be considered as having a norm-proofing function, such as social interactions, peer groups, governments or individuals, as well-accepted instances.

Standards refer to the moral principle and/or legal norms that are formed based on the virtue or duty/obligation of the subject judged by the instance. According to Brinkmann (2013), a range of norm types can be distinguished along an assumed continuum ranging from institutionalised norm types, such as positive law norms and legal sanctions, to less institutionalised norms including soft law, moral norms and normative expectations. Norms can be defined as "*counterfactually stabilized (normative) behavioural expectations*" (Pattaro, Rottleuthner, Peczenik, Shiner, & Sartor, 2007, p. 164). The distinction of Luhmann and Albrow (1985) between cognitive and normative expectations offers a valuable theoretical basis for understanding standard components in the characterisation of responsibility. In their description of cognitive expectations, Luhmann and Albrow (1985) argue that expectations can be revised or dropped if experiences prove them to be different to what was anticipated in the early stages. In contrast, normative expectations can be upheld and became stable counterfactually, with them not needing to be changed even if they are not met (Gould, 1999). The essential distinction for Luhmann and Albrow (1985), however, is that when cognitive expectations are not met, new knowledge is needed, while normative expectations are usually maintained and the activities that violate the norms are sanctioned or prosecuted. In the context of GM food, farmers for instance might be expected to be more involved in the food value chain (FVC) compared to retailers and consumers. If they are expected to develop their own standards and labels addressing specific consumer animal welfare concerns that are not covered by official law and frequently fail, consumers would be better off revising their (cognitive) expectations in order to minimise the aggravation they feel as a result of counting on the farmers' involvement. However, if the law postulates that industries are accountable for adhering to food safety regulations, consumers would not revise their normative expectation of industries being responsible for food safety, even if a large number of them failed to take responsibility. Thus, while the law remains in force, consumers are entitled to uphold their normative expectations.

Finally, the category of consequences denotes "*a list of actions or judgments that are supposed to take place if a subject has or has not acted in a responsible way*" (Schicktanz & Schweda, 2012, p. 134). In the context of biotechnology, external consequences may include legal punishments, economical penalties or even social sanctions, and internal consequences may be a personal sense of guilt or embarrassment.

1.5.2 Theoretical perspectives on risk responsibility and decision-making

Concepts of risk and responsibility can be considered within the realm of decision-making (Giddens, 1999). According to Giddens (1999, p. 8) "*risks only exist when there are decisions to be taken*" and furthermore "*what brings into play the notion of responsibility is that someone takes a decision having discernable consequences*" (Giddens, 1999, p. 8). Kermisch (2012) analysed conceptually the nature of the relationship between risk and responsibility and concludes that the concepts of risk and responsibility are progressively intertwined. Kermisch (2012) argues that in the engineer's paradigm, the relationship between risk and responsibility is indirect, with the quantitative notion of risk not containing any concept of responsibility. She adds that from a cultural theory perspective, risks are constructed as a result of interactions between social processes and, possibly, the external world.

The cultural theory of Douglas (1985) is recognised as pioneering work in the conception of risk and responsibility. Douglas (1985) believes that risk and responsibility are inseparable in that risk is constructed through the cultural process of the responsibility it engages. According to Douglas (1985), allocation of responsibility largely depends on the type of social organisation. Social organisations are preserved by cultural biases containing the whole cognitive and axiological content (Douglas & Wildavsky, 1983). Hence, responsibility determined by cultural bias and the process inherent in social organisations varies from one society to another. Cultural theory hypothesises that there are four types of social organisations dealing with interpersonal relationship patterns: hierarchical, insulated, individualistic and egalitarian. Cultural theory assumes cultural bias corresponding to each social organisation considered to be affected by a particular type of risk (Kermisch, 2012). Hierarchy doctrine holds victims to be blamed and held responsible.

In cultural theory, insulated societies do not tend to assign responsibility since they do not care about risk (Kermisch, 2012). Egalitarians seek to allocate responsibility to outsiders, while in individualistic societies people claim responsibility (Douglas, 1985; Kermisch, 2012). Douglas's cultural theory concentrates on two types of responsibility: blame and moral responsibility. Moral responsibility is one of the important conceptual dimensions of risk that have been emphasised in the literature (Brinkmann, 2013). Two influential philosophical accounts of moral responsibility are the Kantian and Aristotelian approaches of responsibility attribution (Williams, 2004). The Kantian approach situates responsibility for those actions that are taken with free will and with the ability to exercise self-control. The Aristotelian approach points to the importance of attribution of responsibility and voluntariness. The Aristotelian view discusses coercion and force of circumstances, the role of ignorance in undermining responsibility, and an assessment of the actor's character (Williams, 2004). Williams (2004) summarises three underlying capacities in the Aristotelian approach as the capacity to respond to others' praise and blame, the capacity to exercise deliberate and sustained self-control, and the capacity to grasp how one's conduct is socially understood. The Aristotelian account allows mutual accountability, explaining the shared standards of actions (Williams, 2004).

From a psychological perspective, the framework of Heider (1958) has been widely used for understanding the attribution of responsibility. Psychological attribution research has concentrated largely on the degree of intent, "*what the actor meant to do*" (Hamilton, 1978, p. 316). Hamilton (1978) criticises the dominant psychology model of responsibility attribution and extends it from a sociological standpoint. Hamilton (1978, p. 316) argues that responsibility attribution from the traditional psychology perspective refers to a decision about "*liability for sanctions based on a rule*" whereas, in the social psychology approach, the judgment entails consideration of both what the actor did (physical deed) and what the actor was supposed to do (social roles). Consideration of roles within a responsibility judgment framework provides an opportunity to study the dichotomy of authoritative versus subordinate roles. According to Hamilton (1978, p. 320), the five-stage model of Heider (1958) is central in responsibility attribution literature. Hamilton (1978, p. 320) disputes that in Heider's (1958) model, two factors are vital in the attribution of responsibility: a) internal attribution, the extent to which an actor intended the outcome, which can be inferred from the actor's attitude, character or personality, and b) external attribution, the extent to which the action was caused by sources external to the situation. According to Hamilton (1978), what is missing in Heider's (1958) model is the concept of 'role responsibility' (p. 320). The role of actors is a necessary component in Hamilton's (1978) responsibility judgment model, which "*involves the expectations of others for one's behaviour*" (P, 320).

1.5.3 Food risk responsibility

The concept of risk responsibility has become an integral but diverse element in agri-biotechnology and public debates. Responsibility in the context of gene technology has an elusive role with multiple meanings and implications (Schicktanz & Schweda, 2012). This might explain the dearth of research and lack of scrutiny of risk responsibility associated with agri-biotechnology.

In general, two different perspectives regarding risk responsibility in the food chain can be distinguished in the literature. One perspective is a 'moral reasonable' approach which asserts that risk responsibility depends on the position of the stakeholder in the food chain (Rollin, 2006). Another is the concept of 'shared responsibility', which assumes that all stakeholders in the food chain are responsible for ensuring food safety from farm to fork (Hacker & O'Leary, 2012).

Based on the reasonable moral approach to risk, Rollin (2006, p. 157) states that "*responsibility for food safety at a given point in the chain from producer* *to consumer rests with the person or entity under whose control the management of that risk most plausibly lies*". Based on this plausible ethical principle, responsibility for food safety relates to the place in the food chain where a risk most clearly arises. Rollin (2006) argues that it is the obligation of the food industry to proactively educate the public about reducing food risk, the impossibility of zero-risk environments, and the economic costs to freedom from protectionism. According to this view, actors in the food chain have interwoven legal and moral responsibilities in different positions along the food chain (Rollin, 2006). For example, farmers bear no responsibility for the choking risk due to consumers' failure to chew meat properly (Rollin, 2006, p. 159). At the other end of the continuum, consider the farmer who did not remove antibiotic residues from an animal's system – consumers cannot be blamed since it was not within the consumers' capability to detect the presence of harmful residues (Rollin, 2006, p. 159). Furthermore, despite all the attempts made by a meat processor to control microbial contamination, there is always a risk of some microbial contamination remaining, which may pose food safety problems (Rollin, 2006, p. 159). In this case, neither the producer nor the consumer can be blamed for undesirable events, but it remains the moral responsibility of the industry to communicate it to the public.

Another view is the concept of shared responsibility, which places the legal and moral aspects of responsibility side by side. Shared responsibility advocates that food safety responsibility is shared among all the actors along the food chain (Hacker & O'Leary, 2012). In the shared responsibility view, all the actors in the food supply chain are responsible for ensuring the quality and safety of food. The role of consumers is to monitor and report flawed products and processes. Government's role is to provide an integrated risk assessment framework for ultimately assuring food safety. According to the Food and Agriculture Organization of the United Nations and the World Health Organization (2002), there is global recognition that responsibility must be assigned throughout the food chain from farm to fork. However, the issue is the extent to which consumers consider themselves responsible for risks associated with GM food. Furthermore, risk should not be limited to food safety and health issues alone; rather the concept of risk can be extended to include environmental, socio-economic and ethical dimensions.

There is little research on how consumers allocate responsibility regarding food risks across agents along the food chain. Previous studies have reported mixed results concerning judgements about personal food risk responsibility. Some studies suggest that people assume very high personal responsibility for their own food risks (Redmond & Griffith, 2004b; Van Kleef et al., 2006).

Conversely, other findings indicate that consumers assign more responsibility to other agents in the food chain, such as the food industry (Redmond & Griffith, 2004a), farmers (Erdem, Rigby, & Wossink, 2012) and policy makers (Henderson, Coveney, & Ward, 2010).

Erdem et al. (2012), using best-worst scaling, explored two groups of stakeholders' perceptions of the share of relative responsibility for food safety at each stage of the food supply chain, namely farmers and consumers. They found that both farmers and consumers tend to think that the other group has a greater degree of responsibility for ensuring food safety than either group believes they have for themselves. Krystallis et al. (2007) identified a lack of mutual understanding of food risk responsibility and priorities on risk management practices among significant stakeholders, *i.e.* consumers and food risk experts. The authors indicate that consumers vigorously acknowledge their own responsibility in food risk and support the idea of self-protection, whereas experts view food risk management as a shared responsibility with the emphasis on the role of the state and producers.

Henderson et al. (2010) explored Australian consumers' perceptions of responsibility for food safety. Their study found that governments were viewed as responsible for regulating the quality and safety of food. However, consumers were sceptical about food industry practices for protecting food safety effectively. They also found a substantial and vigorous attitude of personal responsibility (self-protection) among consumers. The results of focus group research in four European countries (Van Wezemael, Verbeke, Kügler, de Barcellos, & Grunert, 2010) indicate that people use both intrinsic (colour, texture and fat content) and extrinsic (labelling, country of origin) cues to assess food safety. The results reveal that consumers tend to trust products (and hence relevant regulations) that are produced in their own country (consumer ethnocentrism) more than those produced in other countries. The overall results contradict the prevailing notion of distrust in the beef production chain in Europe due to recent food scandals. However, participants express some level of distrust in the food industry. These results show that actors in upstream parts of the food chain (production and processing) are trusted least, while the actors active downstream of the industry (distribution and retailing) are more trusted. Respondents consider all the actors (including farmers, veterinarians, inspectors, abattoirs and scientists, as well as regulators) to be responsible for food safety, but not consumers themselves.

The results of studies by Teigen and Brun (2011) show that people consider responsibility judgement as a singular (case-based), rather than a distributional (class-based) phenomenon. In other words, responsibility may be perceived to be divisible between two persons, but it is not divisible among a group of people (Teigen & Brun, 2011). This may be explained through the theory of diffusion of responsibility. Diffusion of responsibility (the bystander effect) is a socio-psychological phenomenon implying a reduced sense of personal responsibility whereby an individual is less likely to take responsibility for action in the presence of others (Ciccarelli & White, 2009; Darley & Latane, 1968). The concept of diffusion of responsibility in the context of risk-taking literature implies increased risk-taking in group decision-making and group polarisation (Wallach, Kogan, & Bem, 1964) if citizens are considered equal members of society. Therefore, diffusion of responsibility comes about when individual members of society perceive less personal responsibility for likely adverse outcomes in the pursuit of risky choices than if deciding alone (Mynatt & Sherman, 1975).

Gaivoronskaia and Hvinden (2005) studied consumers' food risk perception and responsibility for different food risks (including sugar, natural allergens, GM food, allergy from GM food, pesticides, prions, salmonella, antibiotics and hormones) and suggest that personal experiences of food harms (*e.g.* allergies or intolerances) can affect both food risk perception and responsibility judgment. A number of food-related scares and disputes, most notably mad cow disease, dioxin contamination of food and beef hormones, has made European consumers wary of food safety policies (Ansell & Vogel, 2006; Knowles et al., 2007; Lofstedt, 2006). The result of the work of Gaivoronskaia and Hvinden (2005) suggests that both food producers and authorities are held responsible for food risks, but that responsibility judgement may shift in view of different types of food risk. In the case of GM food, a considerable portion of consumers stated that responsibility for the GM food risk (in the form of allergenicity) lies both with the individual and the producer. According to Gaivoronskaia and Hvinden (2005), in sensitive food risk cases policies regarding food risk may shift the burden onto the individual responsibility of consumers. In a rare study, Leikas, Lindeman, Roininen, and Lähteenmäki (2009) conducted a series of multiple regression analyses examining the influence of food risk type (including the risk of consuming GM food) and risk perception (risk scariness, likelihood) on risk responsibility judgment. Leikas et al. (2009) found that consumers' judgments around responsibility for potential risks of GM food were highest for the industry and average for retailers, whereas the perception of personal responsibility was relatively low.

This literature suggests that there is a link between perception of risk and attribution of responsibility. While certain aspects of risk in consumers' GM food decision-making are relatively well researched, much less is known about risk responsibility attribution and its process.

1.6 Consumer acceptance of GM food

The issue of consumer acceptance of innovative food technologies and their implications requires an understanding of the determinants of acceptance or rejection (Frewer et al., 2011). Rollin, Kennedy, and Wills (2011) enumerate factors that shape consumers' views towards new food technologies such as perceptions, knowledge, trust and sociodemographic attributes. Petitpierre et al. (2004) suggest four criteria that determine whether consumers like the food: price, perception, physical characteristics and the final use of the product. Mather et al. (2012) suggest that diffusion of innovation provides valuable insight into determining the uptake of GM technology.

The seminal work of Rogers (1962, 2010) on the diffusion of innovation has led to a great deal of research into consumer behaviour and understanding the controversy around innovative food technologies. Rogers (2010) defines five major criteria that explain differences in the acceptability or adoption of new technology by consumers: complexity, compatibility, relative advantage, trialability and observability. Complexity is the degree to which an innovation is regarded as being challenging to understand and adopt. The unfavourable attitude of EU consumers towards GM foods has to some extent been linked to a lack of knowledge and the complex nature of gene technology (House et al. (2004). However Vecchione, Feldman, and Wunderlich (2015) found a strong positive correlation between consumer attitudes towards non-GM foods and purchase behaviour, but weak correlations between knowledge and behaviour or attitudes. Compatibility refers to the extent to which a new technology is consistent with existing values, past experiences and the needs of likely adopters. It is pointed out that the individual's attitude towards the GM product can be affected by general beliefs (Costa-Font, Gil, & Traill, 2008; Saher, Lindeman, & Hursti, 2006). Relative advantage is the degree to which a technology is perceived as being better than the one it supersedes. Rogers (2010) regards this as economic advantage as well as social recognition, convenience and satisfaction. In connection with biotechnology, this can be translated as perceived risk-benefit trade-offs. Trialability is the degree to which the technology has been tried out prior to purchase or adoption. Trialability can be connected to the availability of GM food in the market and how it affects consumer acceptance. Observability refers to the extent to which the output of the adopted new technology is visible to others. Since genetically modified foods, particularly first-generation GM foods, are considered to be credence goods (Isaac & Phillips, 1999), the relative advantages are not easily perceived by consumers. These criteria will be revisited in the sections below.

1.6.1 Consumer knowledge of GM food

Consumer scepticism towards new technologies in food production are sometimes attributed to consumers being poorly informed (McCluskey, Kalaitzandonakes, & Swinnen, 2016). However, McFadden (2016) found that the effects of knowledge on consumer opinion is complex and non-uniform across types of information (i.e. perceived vs. actual knowledge). A group of studies have assessed the influence of information on consumer acceptance of GM foods (House et al., 2004; Huffman, Shogren, Rousu, & Tegene, 2003). House et al. (2004) examined the impact of knowledge on the acceptance of GM foods. They state that both objective and subjective knowledge influences consumer acceptance of GM foods, although people with a college education or higher are significantly more likely to accept GM food (House et al., 2004). Lusk et al. (2004) examined the effect of information about the potential advantages of agro-biotechnology on consumers' willingness to accept GM foods. They found that information on environmental advantages, health benefits and gains for developing countries significantly decreases the expectation of discounts to accept GM food. In contrast, Scholderer and Frewer (2003) found that respondents may become more concerned after receiving positive information. As these studies conducted experimental auctions with limited samples, the inference credibility of these works has been criticised (Ganiere, Chern, & Hahn, 2006).

Poortinga and Pidgeon (2004) found strong confirmatory bias selecting information that agrees with consumers' existing ideas (known as the assimilation effect) in consumers' perception of genetically modified food. McCluskey and Swinnen (2011) found that both confirmatory bias (selecting information that agrees with the individual's initial attitudes) and negativity bias (negative information having more impact than positive information) affect consumers' decisions. Furthermore, the results of a study by Heiman & Zilberman (2011) showed that framing (positive and negative) influences consumer acceptance of GM food at a given price, although negative framing had a stronger impact on discouraging consumers. Other studies point to the role of the media in shaping consumers' attitudes towards new food technologies (McCluskey et al., 2016). For instance, Bauer and Gaskell (2002) and (Lusk, Roosen, & Bieberstein, 2014) suggest that consumers' suspicious and negative attitudes towards biotechnology may be rooted in unbalanced information about its relative risks and benefits in the media. Consistent with previous research (e.g. Frewer, Howard, & Shepherd, 1997), Lusk et al. (2004) also found that responses to the information provided are significantly determined by initial attitudes toward gene technology. Baker and Burnham (2001a) examined determinant factors of GM food acceptance (GM breakfast cereal) and conclude that consumer behaviour is largely influenced by what people believe, and to a lesser extent by how much they know about food biotechnology.

1.6.2 Consumer attitude towards GM food

A large number of studies have been conducted on attitudes toward foods derived from biotechnology (see, e.g. Bellows, Alcaraz, & Hallman, 2010; Christoph, Bruhn, & Roosen, 2008; Dannenberg, 2009; De Liver, van der Pligt, & Wigboldus, 2005; Evans, Kermarrec, Sable, & Cox, 2010; Frewer et al., 2013; Hess, Lagerkvist, Redekop, & Pakseresht, 2016; Lusk, Jamal, Kurlander, Roucan, & Taulman, 2005; Lusk, McFadden, & Rickard, 2015; Tenbült, de Vries, Dreezens, & Martijn, 2005). A general conclusion often made from available attitudinal studies is that EU consumers have negative attitudes towards GM food (Burton, Rigby, Young, & James, 2001). However, there are studies that show that while the majority of EU consumers are reluctant when it comes to GM food, there are still considerable fractions that support GM food or at least tolerate GM risk (for example Gaskell, 2000; Loader & Henson, 1998). A survey in the UK indicates that only 22 % of respondents would not try GM food, while 9 % would like to try it and 62 % probably would try it, suggesting that British consumers are not strongly against GM foods (Loader & Henson, 1998).

The literature has clearly shown that there is a range of consumer attitudes to GM food (Baker & Burnham, 2001b; Christoph et al., 2008; Costa-Font, Gil, et al., 2008; da Costa, Deliza, Rosenthal, Hedderley, & Frewer, 2000; Ganiere et al., 2006). Costa-Font, Gil, et al. (2008) conducted a literature review and classified the consumers' responses towards GM food into three groups of pessimistic, risk-tolerant or information searchers, and optimistic. Wansink (2004) argues for the de-coupling of risk responses into the components of risk perception and risk attitude. Wansink (2004) distinguishes four different segments of consumers' risk attitudes towards food safety: the accountables, the conservatives, the concerned and the alarmists. The segments are identified based on consumer perceptions of risk as well as levels of pre-existing attitudes towards risk (e.g. cautious versus not cautious). According to Hillson and Murray-Webster (2007), the perception completes the individual's initial risk attitude. Poortinga and Pidgeon (2006) explored the structure of consumers' attitudes toward GM food and found that GM food is evaluated by separate perceived risk and benefit dimensions. Based on these findings they propose a four-way typology of attitudes, consisting of positive, negative, indifferent and ambivalent groups.

An attitude towards GM food can be framed through top-down or bottom-up approaches (Grunert, Bredahl, & Scholderer, 2003). In a bottom-up approach the individual's attitude towards a product is formed as a weighted sum of attitudes to the aspects/attributes of the product and corresponding processes. In the top-down approach, consumers' attitudes towards a product are affected by the individual's values and worldviews. The consumer attitude thus reflects his/her general attitude towards technology, policy the environment etc. (Bredahl, 2001; Grunert, Alsted, & Scholderer, 2004; Grunert et al., 2003; Verdurme & Viaene, 2002). Dake's (1991) findings suggest a systematic relation between worldviews and risk perception towards new technologies. According to Dake (1991), a person's worldview is mediated by their social relations to other people and whether the person is more individual-oriented or more group-oriented (in terms of beliefs about social norms and responsibilities to others). Therefore, attitudes towards GM food depend on both general initial values and the overall risk-benefit trade-off of product aspects.

1.6.3 Risk-benefit perception

A number of scholars consider the risk-benefit trade-off as one of the main determinants of consumer acceptance (for reviews refer to Finucane & Holup, 2005; Frewer et al., 2013), although some researchers (*e.g.* Gaskell et al., 2004) place more emphasis on the role of benefit perception (rather than risk) in consumer acceptance. A great deal of research has been conducted on how consumers perceive food risk (*e.g.* Magnusson & Koivisto Hursti, 2002; Marette, Roosen, Blanchemanche, & Feinblatt-Mélèze, 2010; Redmond & Griffith, 2004b; Siegrist, Stampfli, & Kastenholz, 2009; Webster, Jardine, Cash, & McMullen, 2010; Williams & Hammitt, 2001) and how they evaluate the risk against other food characteristics (*e.g.* Loureiro & Umberger, 2007; Van Wezemael, Verbeke, Kügler, & Scholderer, 2011).

Previous food risk perception studies indicate relative differences in consumer risk perception and acceptance in relation to various gene technologies and types of GM food (Delwaide et al., 2015; Frewer, Howard, & Aaron, 1998; Onyango, Govindasamy, Hallman, Jang, & Puduri, 2006). A group of studies have found that respondents are more receptive to the application of GM to plants rather than animals (Burton et al., 2001; Chen & Raffan, 1999; Finucane

& Holup, 2005; Frewer, Howard, & Shepherd, 1997; James & Burton, 2003; Onyango & Nayga Jr, 2004). The results of a recent meta-analysis (Frewer et al., 2013) on consumer attitudes to GM foods confirmed that plant-related or 'general' applications are more acceptable than animal-related applications. Correspondingly, a number of studies indicate different levels of consumer support for intragenic versus transgenic plants (e.g. Lusk & Sullivan, 2002; Myskja, 2006). Lusk and Sullivan (2002) point out that consumer interest in GM food acceptance increases when genetic modification is based on the host rather than on the insertion of a foreign gene into a plant. Research revealed even more public support for GM products that deliver clear and transparent benefits to consumers (Feldmann, Morris, & Hoisington, 2000; Lusk & Rozan, 2006; Onyango & Nayga Jr, 2004; Riley & Hoffman, 1999). Risk literature also points to the concept of self-control, meaning individuals judge the extent to which they perceive they can control the risk and its consequences while assessing risk (Fife-Schaw & Rowe, 1996; Sparks, Shepherd, & Frewer, 1994). A number of theories have highlighted the role of perceptions of self-control and have suggested that the desire to have an impact on our environment is a common preference (Langer & Rodin, 1976).

An individual's risk perception can be affected by the type of product or trait (De Steur et al., 2013; Frewer et al., 2013; Huang, Qiu, Bai, & Pray, 2006). Moreover studies show that different applications of biotechnology can affect the perception of risk and hence public acceptance (Bonfadelli et al., 1998; Fjaestad, Olsson, Olofsson, & von Bergmann-Winberg, 1998; Frewer & Shepherd, 1995; Hamstra & Smink, 1996; Magnusson & Hursti, 2002). Others have addressed differences in the perception of risk based on whether it concerns a processed product or not (Moses, 1999).

Furthermore, research has pointed to the effect of consumer heuristics of geographical distance on food risk perception (Finucane & Holup, 2005). Foods of local origin are deemed less risky than those of more distant origins (Aerni, 1999; Draper & Green, 2002; Green, Draper, & Dowler, 2003). This may be due to the level of trust consumers have in their own national authorities when it comes to food risk assessment and management compared to other parts of the world.

One of the areas that has been examined by food risk researchers is the trust in social actors (referring to credibility and responsibility of actors) and trust in the source of information (for an overview see Frewer, 2003; McComas & Trumbo, 2001). Relationships between trust and public attitudes to GM food have previously been verified (Connor & Siegrist, 2010; Frewer, Scholderer, &

Bredahl, 2003; Poortinga & Pidgeon, 2004; Poortinga & Pidgeon, 2006; Scholderer & Hagemann, 2006; Søndergaard, Grunert, & Scholderer, 2007) Green et al. (2003) point out that people use trust in food system actors (*e.g.* retailers, regulatory institutions) as a heuristic proxy to evaluate safety. More specifically, consumer acceptance of GM food is expedited by such factors as reliability of biotechnology research institutes, GMO technological experts and regulatory bodies (e.g. Zhang, Chen, Hu, Chen, & Zhan, 2016). In fact, consumers compensate for their inability to infer food safety (known as credence attribute) by conferring trust in the food chain actors (Berg, 2004; Frewer & Van Trijp, 2006; Siegrist & Cvetkovich, 2000). In connection with technologies involved in food production, it has been acknowledged that the significance of trust in actors in the food chain is likely to be greater where there is a lack of public knowledge about those technologies (Frewer, Howard, Hedderley, & Shepherd, 1996; Thompson, 1987). Trust is particularly imperative where the precise evaluation of risk is lacking, which is the case with genetically modified food (Frewer, Howard, Hedderley, et al., 1996; Sparks, Shepherd, & Frewer, 1995).

Other studies carried out previously have found that cultural differences also significantly affect risk perception (Englander, Farago, Slovic, & Fischhoff, 1986; Goszczynska, Tyszka, & Slovlc, 1991). Even political affiliation is considered as a reference point around which a particular reaction to a risky condition is maintained (Kellstedt, Green, Guth, & Smidt, 1996; Zaller, 1992). Costa-Font, Mossialos, and Rudisill (2008) examined the political and ethical anchoring effect and they confirm that political affiliation can play a key role in risk perception of credence goods and in particular GM food.

A number of scholars have found that attitudes to foods derived from biotechnology depend on demographic factors such as gender (Burton et al., 2001; Christoph et al., 2008; Ganiere et al., 2006; Hossain, Onyango, Schilling, Hallman, & Adelaja, 2003; Koivisto Hursti, Magnusson, & Algers, 2002; Napier, Tucker, Henry, & Whaley, 2004; Nayga, Fisher, & Onyango, 2006; Zhong, Marchant, Ding, & Lu, 2002), age (Ganiere et al., 2006; Hossain et al., 2003; Li, Curtis, McCluskey, & Wahl, 2002; Nayga et al., 2006; Zhong et al., 2002), income (Kimenju & De Groote, 2008; Oda & Soares, 2000) and education (Baker & Burnham, 2001b; Ganiere et al., 2006; Kimenju & De Groote, 2008; Koivisto Hursti et al., 2002; Lusk & Sullivan, 2002; Mucci, Hough, & Ziliani, 2004; Zhong et al., 2002). However, the effects of demographic variables are inconclusive. For instance, the work by Curtis, McCluskey, and Swinnen (2008) shows that highly educated and affluent consumers are often the ones who have the most negative attitudes, while House et al. (2004) found that people with a higher level of education are more likely to accept GM food (House et al., 2004).

Furthermore, consumer research proposes that in addition to risk perception, the perception of potential benefits also plays a major role in consumer reactions (Frewer et al., 2003; Gaskell et al., 2004; Lusk et al., 2015; Onyango & Nayga Jr, 2004). Some researchers (e.g. Gaskell et al., 2004) place more emphasis on the role of benefit perception (rather than risk) in consumer acceptance. Overall, most people in Europe associate GM foods with risks and, in the absence of particular benefits, reject it (Torgersen, 2004). According to Torgersen (2004), the reception given to GM food largely depends on the trade-off people perceive they are getting in exchange for the acceptance of certain risks.

1.6.4 Tangible benefits

The first generation of GM crops to be commercialised focused on agronomical advantages to farmers rather than consumer benefits. According to (Gaskell et al., 2006; Lucht, 2015); Torgersen (2004), the lack of tangible benefits to consumers is often associated with the general scepticism of Europeans towards GM food.

Farm-level economic impacts from agronomical advantages include cost savings (Qaim & Traxler, 2005), higher yields (Kathage, Qaim, Kassie, & Shiferaw, 2012) and a pronounced reduction in insecticide use (Bennett, Buthelezi, Ismael, & Morse, 2003; Qaim & Traxler, 2005). A recent meta-analysis by Klümper and Qaim (2014) reviewed the performance of a variety of GM corps in different countries and concludes that farmers who adopted GM crops benefited from economic advantages (such as higher income, cost savings etc.), but these benefits have not been appreciated by consumers. In contrast, a large body of studies have indicated consumers' willingness to pay a premium to avoid GM food (For details see Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014). In a few cases, consumers showed a desire to choose GM food if it is offered at a discount (Grimsrud, McCluskey, Loureiro, & Wahl, 2004; Hu, Zhong, & Ding, 2006; Huffman, 2010; Noussair, Robin, & Ruffieux, 2004).

However, acceptance of GM products increases with direct, tangible benefits for the consumer, such as biofortified rice (De Steur, Liqun, Van Der Straeten, Lambert, & Gellynck, 2015), fresh vegetables with reduced insecticide treatment (Boccaletti & Moro, 2000) and enhancement of the Omega-3 content of foods (Hartl & Herrmann, 2009). Such health and nutritional improvements are being promised by the second generation of GM products and seem to be more appealing for consumers in developing countries. Since nutritious food is already accessible in Europe, consumer perception of its benefits is not the same as those in developing countries (Curtis, McCluskey, & Wahl, 2003; Gaskell et al., 2006). In fact, Europeans are often sceptical about changing their food system and consider it unnecessary (Curtis, McCluskey, & Wahl, 2004). Even in developed countries, despite the fact that most of the studies found a willingness among consumers to pay premiums for non-GM food over GM food (Baker & Burnham, 2001a; Carlsson, Frykblom, & Lagerkvist, 2007; Huffman et al., 2003; Kaneko & Chern, 2005), there is evidence that reject a priori assumed superiority of non-GM foods (refer to Ganiere et al., 2006). For example in Lusk, Daniel, Mark, and Lusk (2001) and Lusk (2003), some respondents were willing to pay premiums for GM foods that have tangible benefits. Kaneko and Chern (2005) also reported that a portion of consumers were willing to pay a premium for GM products. Mather et al. (2012) conducted an experiment in six EU countries and found that consumers bought spray-free GM fruit at roadside stalls when it was offered at a discount.

Several studies have verified that consumers in developing countries are more receptive to GM food that has direct benefits. For instance, Li, Curtis, McCluskey, and Wahl (2002) reported on Chinese consumers' willingness to pay more for GM fortified rice than for GM soybean oil because of the nutritional value of GM rice. A few other studies have also found a willingness among consumers to pay a premium for enriched GM foods in India and Brazil (Anand, Mittelhammer Ron, & McCluskey Jill, 2007; González, Johnson, & Qaim, 2009). Nevertheless, the appeal of direct consumer benefits is not supported universally across all lower income countries (Fernandez-Cornejo et al., 2014). Lin et al. (2006) reported Chinese consumers' willingness to pay a premium price for non-GM foods. In Romania, Curtis and Moeltner (2007) found that consumers are willing to purchase non-GM versus GM.

A meta-analysis conducted by Lusk et al. (2005) reveals that the perception of tangible benefits explains the amount of the premium that consumers will pay for a GM product. Research by Gaskell et al. (2004) regarding risk perception has shown that in fact the absence of benefits plays a decisive role in public decision-making. However the benefits for EU consumers have marginal effects. According to Torgersen (2004) the reason for the marginal effects of benefits (and limited importance) in an individual's decision-making is that "*usually, the benefit of an innovative technology is taken for granted – if there were no benefits to it, an innovator would not engage in the costly activity of developing the technology*".

1.6.5 Market availability

A number of scholars have noted the lack of studies on consumer acceptance of GM food using real GM products in real markets (Knight, Mather, Holdsworth, & Ermen, 2007; Powell, Blaine, Morris, & Wilson, 2003). A few studies have looked at consumer behaviour in real market conditions (Aerni, 2011; Aerni, Scholderer, & Ermen, 2011; Mather et al., 2012). In an experiment in Switzerland, Aerni et al. (2011) showed that consumers will purchase GM food if it is available on the market. Consumers were given the options of choosing between organic maize bread, conventional bread or bread made from GM maize. Remarkably, sales rose on average by about 30 % when all three varieties of breads were offered than when GM bread was excluded. The authors conclude that the availability of GM foods among conventional products does not deter consumers. In a study conducted in six countries (including Sweden) (Knight et al., 2007), consumers were given the choice of fruits labelled either ‘organic’, ‘conventional’ or ‘spray-free GM’ in real market situations and with different price treatments. In these experiments consumers preferred organic when the prices for the three options were identical. The preference for buying GM fruit soared in most countries when it was offered at a discount and the organic fruits were at a premium price.

Due to a restrictive regulatory system, just a few GM crops are authorised for cultivation in the EU (Lucht, 2015). The total GM crop area cultivated in Europe was 136,000 hectares in 2016, while the global GM crop area was 185.1 million hectares. Among EU countries, Spain has a significant cultivation of GM crops (Bt maize) followed by Portugal, the Czech Republic and Slovakia on a more limited scale (James, 2016). Therefore the lack of availability of GM products in EU markets cannot only be linked to unanimous public refusal, but rather to stances taken by other actors in the food chain such as retailers (Aerni, 2013; Lucht, 2015).

1.6.6 Social interactions

Social interactions affect consumer acceptance of GM food. From the perspective of diffusion of innovation theory, Mather et al. (2012) point to the importance of social acceptance in determining the uptake of biotechnology. In addition to cognitive factors such as risk perception, external influences such as opinion leaders, governmental policies and social links can affect the technology diffusion process (Nakandala & Turpin, 2016).

The Knight’s et al. (2007) experiment revealed consumers’ willingness to purchase GM fruits if discounts were offered. The same choice experiment was conducted (Mather et al., 2012) using a questionnaire and the results of the stated preferences indicate that consumer preference for GM fruit shrinks significantly, even with a discount. The authors explain this difference using social stigma theory. In this view, consumers' responses are influenced by societal pressures and social desirability, as a human tendency to cast oneself in a way that is viewed favourably by others. The discrepancy between behavioural intention and actual choice has also been acknowledged in other studies (Arts, Frambach, & Bijmolt, 2011; Belk, 1985; Lusk, 2003; Morwitz, Steckel, & Gupta, 2007).

1.7 Consumer decision-making

The micro-level framework on consumer acceptance and favourability has come to integrate its underlying determinants in the form of cognitive variables (perceptions of benefits and risks, attitudes and food knowledge) concerning sociodemographic factors and trust in information about GM. In addition, willingness-to-pay studies have sought to determine the economic value of GM foods to consumers (Costa-Font, Gil, et al., 2008; De Steur, Blancquaert, Lambert, Van Der Straeten, & Gellynck, 2014; Frewer et al., 2013). However, as indicated by Frewer et al. (2013), an understanding of consumer acceptance of GM foods would ultimately require an understanding of the consumer's actual decision-making process.

1.7.1 Food choice theories

By developing the variety of food technologies and ingredients, food choice has become one of the major concerns in consumers' decision-making (Grunert, 1997). Food choice is considered to be a complex decision-making process and there is no commonly agreed framework for explaining consumer behaviour towards food technologies (Grunert, 2017; Marreiros & Ness, 2009).

Two lines of theories underline existing research on consumers' food choice. On the one hand, there is a group of theories that assume rational consumer decision-making (Becker, 1976), focusing on consumers weighing up the costs and benefits of each alternative. Theories such as the subjective expected utility (Savage, 1961), theory of reasoned action and planned behaviour (Ajzen, 1991) and health belief theory (Glanz, Rimer, & Viswanath, 2008) can be put in this category. On the other, there is a line of reasoning that suggests that decision-making does not necessarily follow the rational axiom, but instead that some psychological and cognitive factors account for differences in consumer responses. This line of thought includes theories such as prospect theory

(Kahneman & Tversky, 1979), anchor theory (Ariely, 2008), and self-protection stages theory (Weinstein, 1988). Common to both lines of theory is the imperative role played by risk perception in consumers' food-related decision-making. Lately, dual process models (Dijksterhuis & Nordgren, 2006; Evans, 2003; Kahneman, 2011) have been proposed to combine these two perspectives. A dual process model posits that there is an implicit (automatic) unconscious process and an explicit (controlled) process underlying a person's decision-making.

Marreiros and Ness (2009) have reviewed the most widely used frameworks to explain and predict consumer food choice, including the decision process of Engel, Blackwell, and Miniard (1995), Grunert's (1997) Total Food Quality Model (TFQM), and Zeithaml's (1988) extensions. The fundamental idea behind Grunert's (1997) TFQM and extensions is the distinction between pre- and post-purchase evaluations. TFQM concerns consumers' quality evaluations and expectations based on different cues. The Engel et al. (1995) model consists of decision process stages (i.e. problem recognition, search, pre-purchase alternative evaluation, purchase, consumption, post-purchase alternative evaluation and divestment), and environmental (e.g. culture) and individual (e.g. attitude, personality) variables influencing the decision process. In the Engel et al. (1995) model, the acceptance or purchase behaviour is not the final stage of the decision-making process. In fact, consumer's satisfaction/dissatisfaction from the post-purchase evaluation reactivates the information-processing mechanism.

1.7.2 Decision process and novel technologies

A large body of research suggests that consumers have become more concerned about the food supply system and emerging novel food technologies (Frewer, Howard, Hedderley, & Shepherd, 1997; Mucci & Hough, 2004; Sorenson & Henchion, 2009). Frewer (1998) points out that in addition to sensory properties (and other traditional food choice elements), a consumer's perception of novel food is affected by other factors such as ethical concerns, environmental impact, and trust in risk regulators and scientists. Ronteltap, Fischer, and Tobi (2011) conducted a systematic review of a sample of 107 papers on consumer acceptance of novel technologies, and identified a number of predominant approaches applied such as the Theory of Planned Behaviour (TPB), the Technology Acceptance Model (TAM), the Health Belief Model, and the Psychometric Paradigm. TPB suggests that performing the activity depends on both motivation (intention) and ability (behavioural control). In fact intention is influenced by attitude (i.e. the extent to which an individual has a positive or negative feeling towards engaging in the event), together with perceived behavioural control (i.e. if the person believe that he/she can perform the behaviour) and social norm (i.e. whether significant other people are likely to support the activity) (Ajzen, 1991). The TAM, originally developed by Davis (1989), posits that an individual's acceptance of a new technology is determined by their behavioural intention, which in turn is influenced by their attitude to using the technology. Hence, it can be regarded as an extension of Fishbein and Ajzen's (1975) theory of reasoned action. The Health Belief Model postulates that a health-related behaviour is expected when it is believed that harm can be avoided and there is an ability to perform the behaviour successfully.

Research within the psychometric approach and risk-benefit evaluation has emphasised the role of heuristics rather than rational weighing up of risks and benefits. Among these, affect has been most frequently applied in analysing consumer risk perception (Finucane, Alhakami, Slovic, & Johnson, 2000; Loewenstein, Weber, Hsee, & Welch, 2001; Siegrist, Keller, & Cousin, 2006; Slovic, Finucane, Peters, & MacGregor, 2002a, 2002b; Slovic, Finucane, Peters, & MacGregor, 2004b). Another line of research has highlighted the effect of trust as a single heuristic affecting risk-benefit perception (Siegrist, Cousin, Kastenholz, & Wiek, 2007) or as a collective construct operating in combination with affect (Siegrist, 2000; Siegrist, Gutscher, & Earle, 2005). TAM has been used most frequently overall followed by TPB, but in relation to food technology, the psychometric paradigm (and risk-benefit perception) is the dominant theoretical approach.

1.7.3 Food decision-making and GM technology

Based on a literature review, Costa-Font, Gil, et al. (2008) suggest an explanatory process of GM food decision-making. In this model, attitudes towards GM food are derived from three main interrelated determinants such as an individual's values, knowledge and risk-benefit perception. In agreement with previous research (Pope, Voges, Brown, & Forrest, 2004; Verdurme & Viaene, 2003b), Costa-Font, Gil, et al. (2008) highlight the importance of consumers' values and knowledge of GM food. In addition, cognitive variables such as consumer perceptions of GM food have an important influence on consumer acceptance (Baker & Burnham, 2001a; Bredahl, Grunert, & Frewer, 1998; Li et al., 2002b), especially if they refer to risks and benefits (Costa-Font et al., 2008; Frewer & Shepherd, 1995; Roosen et al., 2005). Finucane and Holup (2005) conducted a literature review on the psychological and cultural factors affecting the perceived risk of genetically modified food and conclude that risk is a social construct and hence perception of risk depends on the social and cultural context. Building on the Costa-Font, Gil, et al. (2008) model, De Steur et al. (2014) proposes a conceptual framework of GM food decision-making in which socioeconomic factors are also considered. The cognitive determinants are the most agreed components in existing proposed frameworks. As suggested by Marreiros and Ness (2009) and Engel et al. (1995), these cognitive elements are affected by external factors such as regulatory context and the behaviour of others. Despite the importance of context in forming consumers' decision-making related to GM food, its inclusion remains a topic for discussion.

One caveat with the extant GM food decision-making frameworks (see Costa-Font, Gil, et al., 2008; De Steur et al., 2014) is that these models use acceptance/rejection as the endpoint of decision-making, while little is known about consumer satisfaction (see Engel et al., 1995) in the decision-making process around biotechnology in foods. Satisfaction is referred to as an affective emotional or cognitive feedback (utility outcome) of the decision-making process (Berridge & O'Doherty, 2014; Kahneman, Wakker, & Sarin, 1997; Lévy-Garboua & Montmarquette, 2007).

1.8 Satisfaction with versus acceptance of GM food

In the last decade, there has been emerging literature about frameworks of consumer decision-making regarding GM food. However, this literature uses acceptance/rejection as the endpoint of decision-making (see Costa-Font, Gil, et al., 2008; De Steur et al., 2014), while satisfaction/dissatisfaction as an affective response or cognitive feedback (Berridge & O'Doherty, 2014; Kahneman et al., 1997) is overlooked in these frameworks. Satisfaction is a cognitive heuristic in the form of an acceptance threshold that entails consumers' evaluation of the decision in comparison with the available alternatives. Kahneman et al. (1997) makes a distinction between decision utility and experienced utility (for detail refer to Berridge & O'Doherty, 2014; Kahneman & Thaler, 2006; Lévy-Garboua & Montmarquette, 2007; O'Doherty, 2011). Decision utility refers to the preference for available choices whereas experienced utility is the affection response that an individual realises once the choice has been made (Kahneman & Thaler, 2006; Robson & Samuelson, 2011).

Kahneman and Sugden (2005, p. 167) suggest experienced utility as a cumulative of momentary measures of well-being, known as 'instant utilities'. In fact, instant utility reflects an absolute measure of utility that a person is experiencing at any given time. A summation of momentary instant utilities reflects the amount of 'experienced utility' over a certain time period. Kahneman and Sugden (2005, p. 167) define decision utility as an *ex ante* attitude that influences the individual's choice. In contrast, experienced utility considered as an *ex post* hedonic experience results from acts of choice. In other words, decision utility can be considered as the preference for available choices, whereas experienced utility is the affection response that an individual realises once the choice has been made (Kahneman & Thaler, 2006; Robson & Samuelson, 2011).

1.8.1 Theories of consumer satisfaction

Consumer satisfaction has long been a particularly salient concern in the field of consumer research. Increased interest in it has therefore led to a relatively meagre amount of research designed to quantify and assess the determinants of consumer satisfaction and dissatisfaction. Reviews of literature (Athiyaman, 2004; Day, 1977; Erevelles & Leavitt, 1992; LaTour & Peat, 1979; Yi & Zeithaml, 1990; Ölander, 1977) suggest a number of theoretical foundations for understanding satisfaction, including equity theory, attribution theory, affective models and the expectancy-disconfirmation paradigm.

Equity theory proposes a relational satisfaction concept based on the ratio of the outcome to inputs. As applied to consumer research, satisfaction is the perception of the fair/unfair distribution of resources in social exchanges. Attribution theory examines how an individual employs information to arrive at causal explanations (judgments) for events (Fiske & Taylor, 1991). Attribution theory and the concept of 'locus of causality' (Folkes, 1988) applied in consumer research imply that internal factors (*e.g.* the consumer's own effort) are generating higher satisfaction than external causes (*e.g.* the salesperson's recommendation) (Athiyaman, 2004). The expectancy- disconfirmation paradigm has been the dominant approach to study consumer satisfaction in the past few decades (Oliver, 1980). The expectancy-disconfirmation theory is a cognitive consistency model that assumes satisfaction derived from disconfirmation of the predictive expectation (or other standards) and real performance.

The expectancy-disconfirmation paradigm has been developed based on implications from contrast theory, consistency theory and assimilation-contrast theory (LaTour & Peat, 1979). The contrast theory (Engel, Kollat, & Blackwell, 1973) hypothesises that if consumers' expectations of the product exceed the actual performance, this leads to dissatisfaction and *vice versa*. Consistency theory (Anderson, 1973) suggests that inconsistency between the expected and obtained level of performance will result in psychological tension and this cause consumers to perceive product performance as consistent with their expectations. Hence, higher expectations result in higher perceived performance and greater satisfaction. The assimilation-contrast theory (Sherif & Hovland, 1961) puts the emphasis on the role of initial attitude as an anchor for the judgment of obtained performance. In fact, assimilation or contrast effects will occur as a function of the amount of discrepancy between initial attitude and actual performance (LaTour & Peat, 1979). The assimilation will occur if the degree of discrepancy is small (less discrepancy with their anchor) (Griffin et al., 2010). In this case, the person adjusts the higher expectations (in comparison with actual performance) and therefore ultimate judgment falls within the person's latitude of acceptance and maintains satisfaction. In opposition to this, a contrast effect will occur if the discrepancy is very large, meaning very low performance falls within the latitude of rejection and therefore results in low satisfaction than if expectations match the actual outcome (Griffin et al., 2010; LaTour & Peat, 1979).

The core of expectancy disconfirmation theory is based on the comparison between choice outcome and a standard. Yüksel and Yüksel (2008) point to the number of extensions or competing theories with the expectancy disconfirmation theory based on different judgment standards, such as La Tour & Peat's (1979) "comparison level theory" (prior experiences), Sirgy's (1984) "evaluative congruity theory" (cognitive congruities), and Westbrook and Reilly (1983) "value percept theory" (value-perception). Despite extensive approval of it in the consumer satisfaction literature, the expectancy-disconfirmation paradigm has been challenged (Westbrook & Reilly, 1983). First, what is expected in a product does not necessarily correspond to what is valued by consumers (Westbrook & Reilly, 1983).Yet, a major problem with the disconfirmation of expectations theory is that it fails to realise expectations until after the choice is made (Westbrook & Reilly, 1983). In other words the expectancy-disconfirmation paradigm does not provide a sufficient prediction in pre-purchase circumstances. This is an important issue in new product development and the future context in which choices are made.

Oliver (2014) introduces alternatives and supplementary comparative operators such as the need for fulfilment and quality judgment. Oliver (2014) proposes a curvilinear model of satisfaction known as 'expectation-confirmation theory' based on need gratification. The expectation-confirmation theory posits that quality performance is examined based on whether the features meet, fall short or exceed customers' needs. The underlying assumption in need gratification theory is that satisfaction is generally determined through the identification of critical attributes independently from expectation. The basis of the need satisfaction theory is built on the distinction between lower-level and higher-level need fulfilment. As pointed out by Oliver (2014), disconfirmation and need fulfilment are both linked to satisfaction, but in an independent way.

Developments in the need gratification theory have led to identifications of categories of attributes such as bivalent satisfiers (can cause both satisfaction and dissatisfaction), monovalent dissatisfiers (causing dissatisfaction only when not present in the product) or monovalent satisfiers (corresponding to a higher need state that can only relate to satisfaction) (Cadotte & Turgeon, 1988; Oliver, 2014, p. 149).

Furthermore, the work of other researchers (*e.g.* Mackoy & Spreng, 1995) acknowledges the asymmetric and multidimensionality effect of the satisfaction construct. Asymmetric implies that satisfaction can simultaneously have two dimensions, satisfaction and dissatisfaction, for the same consumer and the same consumption experience. The asymmetric effect has been tested and confirmed across different contexts (Füller & Matzler, 2008). Multi-attribute models of consumer satisfaction, including the 'theory of attractive quality' known as the Kano model (Kano, Seraku, Takahashi, & Tsuji, 1984), have been developed to assess consumer evaluation of a multi-attribute product in pre-purchase situations. The Kano model suggests that a consumer's overall satisfaction with an object depends largely on their attitude to several sub-characteristics (attributes) of the object (Solomon, 2010, p. 288).

1.8.2 The Kano model

The *Kano model* is a theory of product development and consumer satisfaction developed by Noriaki Kano and his colleagues (1984). The Kano model departed from conventional models of consumer behaviour in that it posits that the relationship between the performance of a product attribute and the satisfaction/dissatisfaction level is not necessarily linear (Riviere, Monrozier, Rogeaux, Pages, & Saporta, 2006; Rivière, Saporta, Pagès, & Monrozier, 2005). Kano theorises that customer satisfaction falls into five performance categories: attractive (A), one-dimensional (O), must-be (M), indifferent (I), and reverse (R) quality dimensions (see Fig. 4).

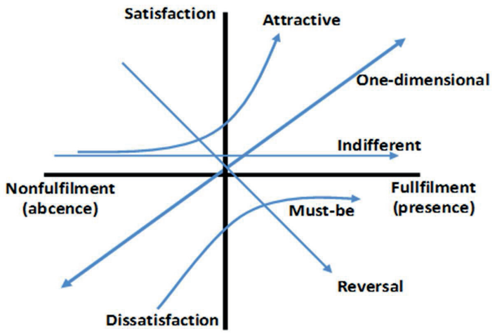

Figure 4. Kano's diagram of attribute categories (Berger et al., 1993, p. 4)

Figure 4 represents the relationship between attribute fulfilment and satisfaction/dissatisfaction. The x-axis ranges from nonfulfillment of an attribute or absence of the element in the product/service or process to completely fulfilled condition. The y-axis ranges from an absolutely dissatisfied feeling to the most satisfied. The attribute fulfilment in the Kano literature refers to the presence of a characteristic in the product/service or its performance. The core idea of the Kano model is that some product attributes matter more to consumers and some do not matter at all, nevertheless consumers' evaluations of each attribute contribute to their overall satisfaction.

In the Kano model, an attractive quality provides satisfaction when it is fulfilled completely, but does not cause dissatisfaction if it is not present. A one-dimensional quality attribute is one that results in satisfaction when fulfilled and dissatisfaction when not fulfilled. A must-be attribute is taken for granted when fulfilled, but results in dissatisfaction when not fulfilled. Increasing the degree of fulfilment on must-be attributes provides diminishing returns in terms of consumer satisfaction; conversely the absence of or decrease in attribute performance results in extreme dissatisfaction. The indifferent category refers to the attributes that will not affect consumer satisfaction. Reverse quality refers to a degree of product features that puts some consumers off. Several studies have suggested that these attributes evolve over time (Vargo, Nagao, He, & Morgan, 2007). Based on the diffusion of innovations theory (Rogers, 2010), what is regarded as an attractive attribute today might become a must-be or even indifferent feature tomorrow.

A typical Kano analysis constructed through a questionnaire consists of pairs of functional and dysfunctional query statements for each product attribute. The functional form question captures the respondents' response if a product has a certain attribute, and the dysfunctional form of question captures the respondents' response if the attribute is not present in the product (or is not fulfilled). To each pair of questions, the respondents can choose one of five possible scales of "*I like it*", "*It must be that way*", "*I am neutral*", "*I can tolerate it*" and "*I don't like it*" (Berger et al., 1993, p. 5; Oliver, 2014, p. 152). A typical Kano questionnaire with functional/dysfunctional queries for a hypothetical attribute is presented in Table 2.

Table 2. *Hypothetical Kano questionnaire (Berger et al., 1993, p. 5; Oliver, 2014, p. 152)*

Kano question (statements)	**Answer**
Functional form of the question (*e.g.* If the product contains component X, how do you feel?)	☐ I like it ☐ I expect it that way ☐ I am neutral ☐ I can tolerate it this way ☐ I don't like it
Dysfunctional form of question (*e.g.* If the product does not contain component X, how do you feel?)	☐ I like it ☐ I expect it that way ☐ I am neutral ☐ I can tolerate it this way ☐ I don't like it

The collected responses are aligned with the Kano's evaluation table (Oliver, 2014, p. 153) revealing each respondent's perception of the product attribute. It should be noted that there are other variations of the Kano evaluation table, which result in a slightly different interpretation of attribute categories (see for instance Berger et al., 1993; Grigoroudis & Siskos, 2009; Lee & Newcomb, 1997; Neysi & Dadkhah, 2013; Sauerwein, Bailom, Matzler, & Hinterhuber, 1996; Xu et al., 2009). The Kano evaluation table comprises the intersecting possibilities of the above scales with regard to both functional and dysfunctional questions (see Fig. 5).

		Dysfunctional form of question				
		Like	Expect it	Neutral	Tolerate it	Dislike
Functional form of question	Like	**Q**	**Q**	**A**	**A**	**O**
	Expect it	**Q**	**Q**	**M**	**M**	**M**
	Neutral	**R**	**R**	**I**	**I**	**M**
	Tolerate it	**R**	**R**	**I**	**I**	**M**
	Dislike	**R**	**R**	**R**	**I**	**Q**

A= Attractive, O= One-dimensional, M= Must-be, I= Indifferent, R= Reverse, Q= Questionable.

Figure 5. Kano evaluation table (Oliver, 2014, p. 153)

The Kano classification of a product attribute is acquired based on mode statistics of the survey results across all respondents (see Fig. 6).

Product features	**A**	**M**	**O**	**R**	**Q**	**I**	**Total**	**Q**
Feature X	1	1	**21**				23	**O**
Feature Y		**22**			1		23	**M**
Feature Z	**13**		5			5	23	**A**
…	6	1	4	1		**11**	23	**I**
….	1	**9**	6	1		6	23	**M**

Figure 6. Kano classification (Berger et al., 1993, p. 5)

Kano's results provide a type of data that only allows a qualitative assessment of attributes (Riviere et al., 2006; Wassenaar, Chen, Cheng, & Sudjianto, 2005; Xu et al., 2009). A convenient way of incorporating quantitative measures is to convert these frequencies into scales in terms of the degree of satisfaction/dissatisfaction (Matzler & Hinterhuber, 1998). Kano model suggests calculating two coefficients as the satisfaction and dissatisfaction potential to determine the ability of an attribute to satisfy or dissatisfy, or both satisfy and dissatisfy (Berger et al., 1993; Oliver, 2014). The coefficients are determined through the equations where the numerators for satisfaction potential include the sum of attractive and one-dimensional categories, and for the dysfunctional coefficient consist of must-be and one-dimensional. Both are normalised by dividing across all categories (excluding questionable and reverse categories). The (-1) is multiplied in the dysfunctional potential to indicate the negative potential (Berger et al., 1993).

The consumer satisfaction potential coefficient (CS) ranges from 0 to 1; the closer the value is to 1, the stronger its influence on consumer satisfaction. A CS coefficient that approaches 0 implies that the effect can be neglected. The consumer dissatisfaction (DS) coefficient ranges from 0 to -1; the closer the value is to -1, the stronger its influence on consumer dissatisfaction. A CS coefficient or DCS coefficient that approaches 0 suggests that the effect can be neglected (Berger et al., 1993; Sauerwein et al., 1996). Both measures of coefficients are then depicted on the x- and y-axis of a two-dimensional grid consisting of four regions (see for example Fig. 7).

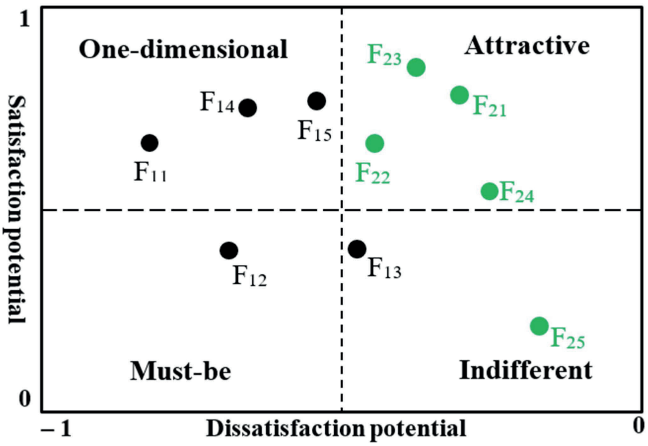

Figure 7. A Kano plot representing the categorisation of components of two hypothetical objects

Two hypothetical cases with their attributes are shown in Figure 7. Each attribute can be represented as pairs of satisfaction and dissatisfaction coefficients (Xu et al., 2009). In fact, the type of attribute can be delineated by the region in which that point falls. The satisfaction potential is indicative of the situation where, on average, the presence of a specified attribute will increase consumer satisfaction (Berger et al., 1993). The dysfunctional potential is inductive of the degree of consumer satisfaction decline from not providing the attribute (Berger et al., 1993). A pair of these two coefficients for each attribute determines the location of a point, indicating the satisfaction or dissatisfaction potential of that attribute. The Kano attribute categorisation and location of five components of two hypothetical products is presented schematically in Figure 7. As presented in Figure 7, the third component of the second profile (F_{23}) has the highest satisfaction potential and relatively low dissatisfaction potential, while component F_{25} has the lowest satisfaction and dissatisfaction potential. Points that are located in the middle scatter plot imply a roughly equal potential to satisfy and dissatisfy (Oliver, 2014).

Despite the power of the Kano model in characterising attributes in terms of consumer satisfaction, research on the application of the Kano model in the multi-decision contexts is nevertheless rare. A multi-decision context may refer to situations that a decision-maker encounters with a number of alternatives, each with a vector of components. Since its emergence, there has been a substantial growth in the number of publications on the conceptual and methodological developments of the Kano model and the theory of attractive quality (for a review of the literature on the theory of attractive quality refer to (for review of the literature on the theory of attractive quality refer to Berger et al., 1993; Füller & Matzler, 2008; Löfgren & Witell, 2008; Witell, Löfgren, & Dahlgaard, 2013; Witell, Löfgren, & Gustafsson, 2011). Despite the contributions made to Kano's theory of attractive quality, more research on alternative approaches is needed (Witell & Löfgren, 2007). While the role of an attribute's quality in satisfaction judgment has been widely studied within multi-attribute satisfaction research, relatively little attention has been devoted to the satisfaction judgment process in multi-product (choice) situations.

2 Research model

There are divergent approaches to the regulation of GM food across different countries and specifically between the EU and US (Lucht, 2015; Martinez, Fearne, Caswell, & Henson, 2007; Wallace & Oria, 2010). A considerable amount of the literature has examined the reasons for different approaches to GM food in the EU and US (Kurzer & Cooper, 2007). Explanations range from differences in the regulatory framework (Dunlop 2000; Vogel 2003), farming system and economic of scale, the impact of the agricultural biotechnology industry, trust in public authorities, food culture, as well as integration and international trade liberalisation (Bernauer, 2003; Gaskell, Allum, & Stares, 2003; Gaskell, Bauer, Durant, & Allum, 1999; Meins, 2003; Phillips & Wolfe, 2001). Even in the EU region there is a striking variation between member states in their acceptance of GM food (Kurzer & Cooper, 2007). Recently, the European Commission approved Directive 2015/412 that permits member states to restrict or prohibit the cultivation of EU-authorised GMOs for food and feed on their respective territories. This policy shift allows more diverse regulation among member states with different contextual implications. Context has a profound effect on people's preferences and decision-making (Kahneman & Tversky, 2000). According to Falk and Szech (2013) individuals' decision-making may differ in different contexts.

Furthermore EU consumer attitudes have been found to be overwhelmingly negative towards GM foods (Hebden, Shin, & Hallman, 2005). It has been suggested that European suspicion of food derived from biotechnology is linked to the perception of associated risks (Laros & Steenkamp, 2004), although other studies suggest that consumer rejection is related more to the absence of tangible benefits (Arvanitoyannis & Krystallis, 2005; Hallman, Jang, Hebden, & Shin, 2005; Poortinga & Pidgeon, 2005). For instance, previous studies have demonstrated more receptive behaviour towards GM food that have more tangible benefits for human health or the environment (Frewer, Howard, &

Shepherd, 1996; Loureiro & Bugbee, 2005; Townsend & Campbell, 2004; Uzogara, 2000) and even the willingness to pay a premium price (Colson & Huffman, 2011). Consumers' acceptance of GM food might be affected after experience of GM products involving clear direct benefits (Grunert et al., 2003). Therefore, it is necessary to examine the effects of policy contextual issues and endogenous preferences (see Palacios-Huerta & Santos, 2004) on consumers' responses to GM food with tangible benefits and how satisfied they are with the choices they make (Papers II and III). In addition, it is important to study the effect of policy context on consumer perception of different dimensions of risk and risk responsibility towards a GM food with consumer benefits (Paper IV).

This chapter presents the conceptual model, the research model and the motivations behind the research model.

2.1 Conceptual model

The literature to date has addressed to the role of perceived risk, risk responsibility, as well as contextual issues on consumer behaviour. Figure 8 outlines the conceptual model used for determining the effect of policy context on perception of risk, own risk responsibility and acceptance of GM food. Research findings suggest an inverse relationship between risk perception and attribution of risk responsibility (Lindell & Perry, 2000; Terpstra & Gutteling, 2008). However, risk constructed as a social phenomenon and endogenous preferences (see Palacios-Huerta & Santos, 2004), given the policy context, can affect the perception of risk (Krimsky & Golding, 1992; Mitchell, 1999; Slovic, 1987; Slovic & Gregory, 1999; Wachinger & Renn, 2010). Keown (1989) found that risk perception is linked to the contextual influences of regulation opportunities to control risk. Hence, changes in policies have implications for different risk dimensions and ultimately for risk perception.

The literature also suggests controllability as an antecedent of personal risk responsibility (see Leikas et al., 2009; Weiner, 1996). Self-control refers to the individuals' judgement of the degree to which they perceive they can control the risk and its consequences while assessing the risk (Fife-Schaw & Rowe, 1996; Sparks et al., 1994). Leikas et al. (2009) examined the relationship between risk perception and controllability with responsibility in relation to GM food and found that the responsibility is only predicted by the controllability.

In addition, a large body of literature has suggested that contextual factors affect consumers' decision-making (Feunekes, de Graaf, Meyboom, & van Staveren, 1998; Grunert et al., 2003). Existing consumer studies on GM food have characterised a unicentric perspective, while in reality decision analysis in most social environments needs to adapt to multi-actor settings (Timmermans, 2004). Consumer behaviour does not take place in a vacuum, rather other stakeholders' views and choices provide inputs in their decision-making process (Fischhoff, 2008; Grunert et al., 2003). For example, Lucht (2015) categorises Sweden as a GM food adopter in which its food industry adopts pragmatic positions and is generally open to agro-biotechnology. However, consumers' concerns about GM food has led major food actors, including retailers, to continue to avoid offering products containing GM ingredients (Desaint & Varbanova, 2013). Therefore, as depicted in Figure 8, changes in food policies governing GM food can affect the contextual implications for FVC actors, which in turn affect consumer choice and satisfaction (Falk & Szech, 2013).

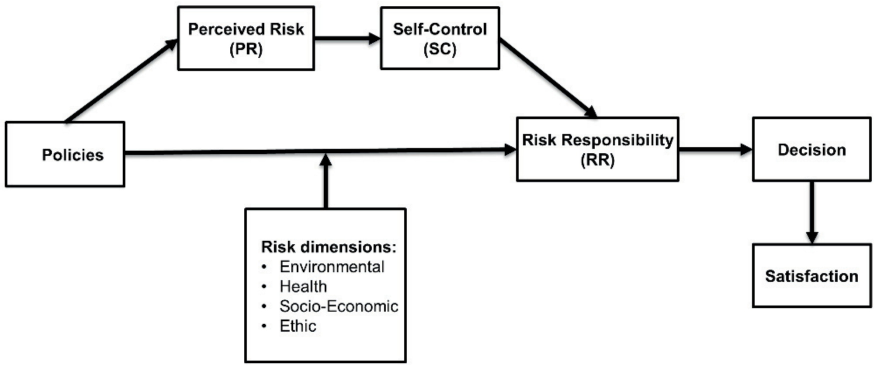

Figure 8. Conceptual model for the effect of policy regime on consumers' choices and satisfaction as well as attribution of risk responsibility (RR) to self through perceived risk (PR) and self-control (SC) depending on the risk dimension (RD)

2.2 Method

With the exception of the first paper, which is based on the empirical data of 214 studies on consumer acceptance of GM food published between 1990 and 2011, Papers II to IV are based on the AFE data collected between June and August 2014. The ultimate aim of the studies in Papers II to IV was to deepen understanding of consumers' decision-making and risk responsibility judgement towards GM food under different policy scenarios. To achieve this, an artefactual field experimental (AFE) design was used for data collection. An AFE is similar to a laboratory experiment except that it draws on non-student participants (Harrison & List, 2004). Thus, the AFE allowed for control of the stimuli and settings, as in a laboratory environment.

Laboratory experiments are a well-established method for studying consumer behaviour and individual preferences (*e.g.* Andreoni & Miller, 2002; Camerer & Fehr, 2004). By controlling exogenous variables, *ceteris paribus*, they allow the researcher to detect the true causes. Plott (1982, p. 1482) points out that "*while laboratory processes are simple in comparison to naturally occurring processes, they are real processes in the sense that real people participate for real and substantial profits and follow real rules in doing so. It is precisely because they are real that they are interesting*." Laboratory experiments often (implicitly or explicitly) express a game. Hence, game theory and experimental economics are strongly related and influence one another. The primary insight of game theory is its 'allocentric' perspective in which the underlying focus is on others' choices instead of an 'egocentric' perspective where the focus of the players is on their own position (Brandenburger & Nalebuff, 1995).

2.2.1 Policy scenarios

A between-subject design was employed. The experiment sessions were designed under four randomised policy scenarios (treatments): (A) banned, (B) research and development (R&D), (C) import only and finally (D) full commercialisation.

In scenario (A), the ban refers to a policy context in which all activities related to the production and commercialisation of GM food are prohibited. The R&D scenario (B) depicts a policy where only activities with regard to research on the application of biotechnology in food production are allowed but not the importation, cultivation or commercialisation of GM foods. In the import-only scenario (C), importation of GM food is allowed but domestic production is not possible. Finally, in the full commercialisation scenario (D), GM as well as non-GM food can be available on the market either under a mandatory labelling policy to inform consumers about the use of biotechnology in the product or without such a labelling requirement.

Paarlberg, Gruhn, Goletti, and Yudelman (2000, p. 4) have classified policy options that might be considered in relation to the use of biotechnology in the agro-food system. They categorise choices based on whether policy makers will support or prevent the application of gene technology from 'promotional' (policy stance that promotes and accelerates the spread of new technology), 'permissive' (policies that are neutral towards the biotechnology, tending neither to accelerate nor slow its spread, but less stringent than banning), to 'precautionary' (protective policies that tend to slow the spread of biotechnology-derived products), as well as ‘preventative’ choice (that has a tendency to block or prohibit entirely the spread of GM crops and foods).

2.2.2 Stimuli

A line of novel potatoes with health and environmental traits were considered as stimuli. The potato is one of Sweden’s most important staple crops (Hallikainen, 2003). Advances in agronomy and breeding developments have made the potato an increasingly important crop in terms of cultivation and consumption on any scale across the globe (Messer, 2012). Europe is the leading potato-consuming continent (per capita basis) and Sweden accounts for just 1.3 % of the EU area under potato cultivation with 1.4 % of the potato yield (Dixelius, Fagerström, & Sundström, 2012).

Using GM, this potato variety has been developed to have a high content of amylose starch by turning off the formation of the second starch component, amylopectin (which has a low glycaemic index). The glycaemic index (GI) represents the level of glucose in the blood, so amylose with a low GI means that the body metabolises this starch slowly and sugars are evenly released, which is particularly important for diabetics and other dietary purposes. This helps the person to have longer satiety and more stable blood sugar. However, regular potatoes contain only 25 % amylose and the rest of the starch content is amylopectin. Hence, the GM potato with high amylose starch has direct health benefits in which the high amylose content is metabolised slowly, providing a low glycaemic index (GI). This makes it a suitable alternative for diabetics and anyone else seeking to improve their diet.

Moreover, as an indirect benefit, amylose starch has beneficial properties for the production of a renewable and biodegradable plastic. One of the largest environmental problems caused by modern farming is nutrient leakage stemming from intensive use of fertilisers. Growing this potato would reduce the use of nitrogen-based fertilisers by 20 % (Svennerstam, Personal communication) which constitutes an additional indirect benefit. The benefits related to the GM potato are hence not limited to consumers, but also relate to main actors within the food value chain.

2.2.3 Samples and recruitment

A total of 535 valid responses were collected in the experiment in three rounds from May to August 2014. Subjects were recruited from Uppsala’s population and aged between 18 and 75. Recruitment was undertaken by sending an invitation letter to 7000 random household addresses. People who were interested in participating signed up on a webpage and received a unique code to participate anonymously. After registering they were able to choose the appropriate time to participate in the study. Participants were informed at registration that upon completion of the study, they would receive a gift card to the value of SEK 300 to be used in a grocery store or cinema of their choice.

2.2.4 Process data

The artefactual laboratory experiments took place in the computer laboratories at Uppsala University. Thirty sessions were held (at different time slots including weekends) with a total of 547 subjects (data from 12 participants were discarded due to incomplete answers or at the request of the participants, leaving 535 valid responses in total). At the beginning of each session, a research assistant gave a brief introduction and explained the terms and conditions with the aim of familiarising the subjects with the experimental procedure before proceeding with the real experiment.

The computer-assisted experiment then consisted of two parts. In the first part, participants assessed their perceived risks with regard to food biotechnology and assigned risk responsibility to the FVC actors (policy makers, farmers, processors, retailers and themselves as consumers) for the risk dimension of highest relevance (personal health, environmental, socioeconomic and ethical). After a short break, in the second part participants were provided with instructions and the stimulus material for the interdependent decision-making part of the study. Measuring consumer preferences in an interdependent context requires all the participants to have "*the opportunity to learn more about their options and expected consequences prior to elicitation of their preferences*" (Renn, 1992a, p. 54). Therefore, respondents were confronted with different decisional contexts (under four policy scenarios of ban, R&D, import and full commercialisation) in which they could see what options were available to FVC actors and what they actually decided. At the end, the respondents were requested to choose a decision based on the given information and possible options. Messick and McClintock (1968) note that an individual's choice in a multi-actor setting is affected by both the individual's preferences and reactions to the decisions of other relevant actors.

2.3 Motivation to the research model

2.3.1 Motivation behind Paper II

The commercialisation of GM food has been a topic of public debate in Europe since its introduction. Previous studies have investigated the consumers' GM food choice and the role of prior attitude versus information (Baker & Burnham, 2001b; Li, McCluskey, & Wahl, 2004), risk and benefit perception (Moon & Balasubramanian, 2003), labelling (De Frahan & Tritten, 2003; Tengene, Huffman, Rousu, & Shogren, 2003), trust in institutions (Komirenko, Veeman, & Unterschultz, 2010; Zhang, Chen, et al., 2016), country of origin (Chambers, Lobb, Butler, Harvey, & Traill, 2007; Xie, Kim, & House, 2014) and financial motivations (Knight et al., 2007; Rigby & Burton, 2006). However, the consumer decision-making does not take place in a vacuum and social factors can influence food decisions (sometimes unconsciously) since attitudes to foods develop through interaction with others (Feunekes et al., 1998). The classical models of decision-making neglect the interdependent decision-making process (Kelly, 2003). According to Falk and Szech (2013), social context affects an individual's decision. They distinguish between the individual decision-making process and decision-making in a social context in which bilateral and multilateral interaction affects consumption choices. In a social context, the choices of other actors in the food chain (endogenous preferences (Palacios-Huerta & Santos, 2004)) provide signals about the consumers' decision-making process (Fischhoff, 2008; Grunert et al., 2003). Thus, as supportive stances taken by food value chain (FVC) actors increase, the likelihood of consumer consideration and acceptance should also increase (Kardes, 1994; Ratneshwar, Shocker, & Stewart, 1987). However, the relationship between the stances adopted by the main FVC actors (including regulators, farmers, food processors and retailers) and consumer acceptance of GM food is underappreciated in the literature. While it is important to consider the role of actions by upstream FVC actors on consumer acceptance of GM food, it is also essential to consider that the actors' behaviour ultimately depends on how the policy is designed. Different policy approaches provide a different state of affairs, which may or not contain a conflict of interest among actors. The policy context might be considered as acceptable by some, but not necessarily all actors (Arts & Tatenhove, 2004). Hence, Paper II investigated whether consumer acceptance of GM food (with direct benefits) is dependent on the policy context and the stances taken by other actors. The literature has pointed to the effects of context, perception of risk and risk responsibility on consumer behaviour, however the focus of Paper II (as well as Paper III) was on the link between policy context and consumer acceptance of GM food.

2.3.2 Motivation behind Paper III

Due to great promises made by biotechnology to help the agro-food sector, a large number of studies have investigated consumer behaviour towards genetically modified (GM) foods since its introduction in the 1990s (for reviews refer to Bredahl et al., 1998; Costa-Font, Gil, et al., 2008; Dannenberg, 2009; Lusk et al., 2005; Rodriguez & Abbott, 2007; Verdurme & Viaene, 2003a). Nevertheless, this literature uses acceptance/rejection as the endpoint of decision-making (see Costa-Font, Gil, et al., 2008; De Steur et al., 2014) and knowledge is limited about the consumers' satisfaction with their decision.

The question is the conditions under which higher consumer satisfaction is expected. Satisfaction can be regarded as affective feedback on the decision-making process. Fischhoff (2008) points out that the behavioural decision framework can accommodate multiple factors, including social and affective elements.

Grunert et al. (2003) outlines an interdependency of decision-making by food value chain actors in the GM food context. According to Grunert et al. (2003), there is no all agreed expectations of GM food among FVC actors. This diversity in stances by FVC actors might be intensified due to changes in the policy context that ultimately induce different consumer responses and different levels of satisfaction. In fact, consumers' GM food choices can be seen in a cause-and-effect decision-making process where the presumptive behaviour of FVC actors affects consumer decision-making (Niou, Ordeshook, & Rose, 2007) and satisfaction as the outcome of this process. Nevertheless, it has been challenging to quantify and assess this satisfaction (Fornell, 2007), particularly in complex environments (Riviere et al., 2006).

Outside consumer food behaviour research, in the past two decades Kano's typology has been widely adopted by researchers and several methodological approaches have emerged to assess its attributes (for reviews see Mikulić, 2007; Oliver, 2014). Thus the Kano typology of key product drivers has become a strategic tool in product selection. While the conventional Kano model offers benefits in the evaluation of attributes and features, Riviere et al. (2006) note that it has not been developed to allow comparisons across products, which is typically what would be needed in product category studies. Hence, an extension of the Kano model is required to compare multiple products with multiple attributes. This measure would therefore aggregate satisfaction with attributes into an overall Kano characterisation that allows comparisons and selection across products so as to identify products that are optimised in relation to consumer satisfaction. The extensions to the Kano model can then be applied in consumer decision-making related to GM food where satisfaction is used as a proxy to measure the outcome utility of possible decision contexts. The decision context includes possible interdependent stances adopted by FVC actors and consumer responses to these decision profiles.

2.3.3 Motivation to Paper IV

Supporters of genetic modification regard it as essential technology for promoting sustainable agriculture with the potential of enhancing crop productivity (first-generation GMOs), enriching foods with nutrients and vitamins (second-generation GMOs), and developing value-added pharmaceutical/industrial crops (third-generation GMOs) (Buiatti et al., 2012; Farré et al., 2011; Naqvi et al., 2011; Ramessar, Sabalza, Capell, & Christou, 2008). Nevertheless, people have expressed various concerns about food derived from biotechnology. These concerns are related to health and safety (Knowles et al., 2007), the environment (Conway, 2000; Pimentel, 2000), ethics (Bauer et al., 1998; Stirling & Mayer, 1999) and socioeconomic concerns (Qaim, 2009; Wibeck, 2002).

A large number of studies have investigated the role of risk perception in consumer food choices in general (Boholm, 1998; Hansen, Holm, Frewer, Robinson, & Sandøe, 2003; Lusk & Coble, 2005; Pennings & Wansink, 2004; Pennings, Wansink, & Meulenberg, 2002) and GM food in particular (Costa-Font, Gil, et al., 2008; De Steur et al., 2014; Frewer et al., 2013). In addition, consumers increasingly recognise their own responsibilities for risk of the foods they consume (Wallace & Oria, 2010). Yet the issue of how consumers can be expected to take responsibility for the risks that they associate with GM food and how they attribute the responsibility for these risks to FVC actors and themselves has been largely ignored.

The literature has identified perceived risk and self-control as cognitive elements of risk responsibility (Ueland et al., 2012). However there is evidence to suggest that responsibility is mainly predicted by controllability (see Leikas et al., 2009; Weiner, 1996). Findings in other research fields suggest that increased perceived risk leads to lower personal responsibility and instead other actors are expected to be more responsible (Lindell & Perry, 2000; Terpstra & Gutteling, 2008). Consumer perceptions with respect to food safety have changed considerably due to more information becoming available in recent decades. Increasing consumers' knowledge about food-borne diseases, safe food-handling behaviours and vulnerable groups, even though this knowledge is sometimes inaccurate, affects the perception of risk and controllability (Wallace & Oria, 2010). According to Gaivoronskaia and Hvinden (2005), policies regarding food risk may shift the burden of responsibility onto consumers. They studied consumers' food risk perception and responsibility for different food risks (including sugar, natural allergens, GM food and allergies from GM food, pesticides, prions, salmonella, antibiotics and hormones) and suggested that personal experiences of food risks (*e.g.* allergies or intolerant reactions) can affect food risk perception and judgement about responsibility.

Furthermore, different approaches to regulating GM food and related policy implications have the potential to affect the perception of associated risks (Wohlers, 2010) and responsibility. However, little attention has been paid to understanding the contextual effects on consumers' perception of GM food risk responsibility. An understanding of public judgement of risk responsibility will facilitate the appropriate implementation of related regulations and, as such, is of direct relevance to policy makers, experts and the public.

3 Summary of appended papers

This final chapter summarises the main findings of Papers I-IV in combination with a section summarising the main findings of the study overall.

3.1 Paper I: Consumers' evaluation of biotechnologically modified food products: New evidence from a meta-survey

Research on the application of biotechnology in food production has been remarkably diverse. Even after decades of development, agro-biotechnology and its application in food production are still being debated and the state of affairs under which people accept GM food is still not fully elucidated. Numerous social science research studies have attempted to understand the behavioural foundations of technology acceptance among members of the general public (for reviews refer to Dannenberg, 2009; Frewer et al., 2013; Hall, Moran, & Allcroft, 2006; Lusk et al., 2005), yet the results are still not conclusive. Therefore, the aim of Paper I was to review and combine information from a large body of consumer research measuring consumers' evaluation of GM food products.

A meta-analysis was performed to examine the systematic evidence in available scientific literature. In total, 1,673 original questions were extracted from 214 different studies (retrieved from 20 databases) covering 58 different countries with responses from more than 200,000 respondents. In contrast to previous systematic reviews (e.g. Lusk et al., 2005), the presented meta-analysis did not focus on a comparison of the reported outcome measures (such as willingness to pay) of the studies, but rather on the descriptive statistics of the survey statements.

The conceptual meta-model was rendered into an equation which stated that the measure of consumer evaluation of biotechnology in food, as reported in studies, was determined by factors such as preferences, income, information and methodology. The empirical model focused on studies that provide descriptive statistics of survey statements as long as they represent consumers' acceptance of GM food assessable on a numerical scale. In order to make the extracted values (empirical representation of consumers' evaluations) comparable across studies, a set of rescaling judgement practices were performed to convert reported scale endpoints into a common benchmark scale.

The results of the mixed effects meta-model showed that the survey questions affected the tone of response. This implied that a research question or statement with positive (negative) connotations about biotechnology tends to be associated with a positive (negative) response. A vast body of literature on research design postulates that response inconsistencies are due to cognitive biases such as wording effect (e.g. Dillman, Smyth, & Christian, 2014; Levin, Schneider, & Gaeth, 1998; Schwarz, 1999, 2014), valance framing effect (e.g. Fischhoff, 2005) and confabulation (e.g. Loftus & Palmer, 1974; Yuille & Cutshall, 1986). The effect of wording has also been confirmed in consumer research on GM food (Curtis, McCluskey, & Wahl, 2004; Lusk, 2003; Scholderer & Frewer, 2003). Paper I showed that studies conducted in the EU focus more often on perceived risk or ethical concerns than studies elsewhere in the world. Nevertheless, when this was controlled for, the results indicated that EU consumers appeared no more reluctant about GM food than people in other countries.

In addition, Paper I provided evidence in support of biotechnologically modified food being largely insensitive to the type of food product. Furthermore, stated advantages such as better taste and improved shelf life did not produce any significant positive response unless health-promoting features were incorporated, while price discounts, increased production and various perceived risks encouraged negative reactions. In fact, consumer evaluations of GM food were mostly driven by their risk perception of the technology rather than of the benefits. The findings shed further light on those aspects that appeared most influential in shaping consumers' assessment of biotechnology in food products. The paper also discussed potential strategies for future research and policy design in relation to these technologies.

3.2 Paper II: Consumer acceptance of food biotechnology based on policy context and upstream acceptance: Evidence from an artefactual field experiment

Recent developments in new food technologies, such as gene modification, have revolutionised the food production system, but have also had diverse effects on consumer perception. Despite a large body of literature on consumer acceptance of genetically modified (GM) food (see reviews by Frewer et al., 2013; Hess et al., 2016; Lusk et al., 2005), knowledge about it is still limited.

Paper II examined the link between consumer behaviour concerning food produced using biotechnology and the actions taken by upstream actors in the food value chain. The decision-making process can be affected by the behaviour of other relevant social groups (Fischhoff, 2008; Granovetter, 1978; Grunert et al., 2003; Rolfe, 2004).

It was also imperative to consider that the stances adopted by upstream actors ultimately largely depended on how policy is formulated. Regulations embedded in food policies defined the context that affects the actors' behaviour. Issues such as labelling, origin of the product and product accessibility were the main components in possible alternative policies towards application of biotechnology in food production. The potential accessibility of GM food raised questions about the appropriateness of current EU traceability and labelling policies. It has been alleged that the current mandatory labelling regime aiming to protect domestic producers has been a trade barrier that imposes a cost on consumers (Marchant et al., 2010). Hence, the question of voluntary versus mandatory labelling policy depends on the consumers' perception of the labelling options, along with the assessment of cost of compliance.

The outcome of four different policy scenarios, ranging from an outright ban on GM products to full commercialisation, was compared in Paper II. The results showed that the policy regulation in place had a decisive influence on consumers' acceptance decisions and that the policy context itself may induce opposition to GM food. The greatest consumer opposition was found in the most restrictive policy scenarios. A similar outcome was observed in cases in which the GM product was not marketed due to actions taken by upstream FVC actors rather than as a result of policy restrictions. In line with previous studies, the results also indicate stronger support for domestic GM products than for imports (e.g. Chambers et al., 2007; Loureiro & Umberger, 2005; Xie et al., 2014). Introducing a mandatory labelling scheme in a scenario where GM produce could be fully commercialised resulted in a significant reduction in consumer rejection.

Moreover, consumers drew inferences and adapted their acceptance decisions in accordance with actions taken by upstream actors. This influence was found to be actor-specific and policy context-specific. In fact, consumer acceptance of GM food increased where other actors in the food chain consistently endorsed it, and in contrast rejection increased if other actors consistently did not endorse it. This meant that the decision by food chain actors to not support GM produce would reinforce the decision to reject such products among consumers who opposed the technology. People are disinclined to get involved in a complex decision-making process when making food choices. Rather, they tend to allocate few cognitive resources and base their decision on heuristics (Heiman & Zilberman, 2011; Johnson & Eagly, 1989; Thaler & Sunstein, 2008). The extent of similarity in FVC stances contributes to cognitive consonance and cognitive complexity in the decision-making process (Ong, Frewer, & Chan, 2017). Hence, consumers are likely to draw inferences from available information on stances taken by other actors. The policy conclusions drawn from these findings were that the chances of successful commercialisation of GM products would increase if actors coordinated their stances.

Furthermore, increasing knowledge about consumer responses to regulatory issue related to GM technology may establish a precedent for how societies can regulate other novel technologies (including animal cloning, stem cell research, and pharmaceutical and food bio-engineering) (Ansell & Vogel, 2006; Bernauer, 2003).

3.3 Paper III: Composite-level analysis of consumer satisfaction data from the Kano model: An application to consumer decision making related to food biotechnology

There is a wide body of literature about consumer acceptance of food biotechnology, in particular GM foods. This literature uses acceptance/rejection as the endpoint of decision-making (see Costa-Font, Gil, et al., 2008; De Steur et al., 2014), and little is known about consumer satisfaction in relation to biotechnology in foods. Satisfaction can be seen as a decision outcome or what has been referred to as “experienced utility” (Kahneman & Thaler, 2006).

The Kano model of satisfaction is one of the most widely used methods to measure satisfaction and has attracted interest in consumer food behaviour research. The model classifies attributes of a given product or service into a typology of five main driver dimensions of satisfaction. This characterisation is particularly relevant for food product developers, since it provides an understanding of the attributes that have the greatest influence on consumer satisfaction and input to product development. While the conventional Kano model has benefits for the evaluation of attributes and features, it has been noted that the model does not allow comparisons across products (Riviere et al., 2006). Thus, the Kano satisfaction model has not yet been useful for strategic selection across products, especially with non-identical features.

The aim of Paper III was therefore twofold. The first aim was to develop an analytical extension of the Kano model to a multiple product/profile environment that would allow researchers and analysts to condense the characteristics of any products/profiles into an aggregated satisfaction measure within the Kano typology. This measure would thus aggregate attribute satisfaction into an overall Kano characterisation to allow comparisons and selection across products to be made in order to identify products that are optimised in relation to consumer satisfaction. A sub-aim was to develop two novel dispersion measures and a bar index to enable evaluation of the heterogeneity and stability of the Kano characterisation of product profiles. The dispersion index revealed the homogeneity among product attributes and the bar index directed strategic product optimisation to enhance overall satisfaction. The extension to the Kano model developed in Paper III allowed the measurement of consumer satisfaction resulting from comparing multiple products with multiple attributes.

The second main aim of the Paper III was to use the extended Kano approach to analyse data collected from an artefactual field experiment assessing consumer satisfaction in relation to decisions concerning food derived from biotechnology. The application of biotechnology in food production has been a contentious issue in Europe and indeed a topic of worldwide controversy in the past few decades. The recent Directive 2015/412 with a provision of 'opt-outs' for member states from the Europe-wide approval system for GM food has paved the way for diverse policy regimes across EU countries. Different policies have different contextual implications for FVC actors. Positions taken by FVC actors in relation to the policies also provide a decision context for consumers with different levels of satisfaction.

Hence, the suggested extensions were used to analyse Kano data from experiments in four scenarios (ban, R&D, import, and full commercialisation). Kano evaluations were undertaken on the behaviour of each actor in the form of decisions made to accept or reject a genetically modified (GM) potato with direct consumer health benefits and indirect environmental benefits. The findings suggested that both consumer choices and satisfaction were dependent on the degree of unanimous stances adopted by upstream food value chain actors in supporting the GM food product. In fact, actors' coherent rejection of GM food resulted in lower consumer acceptance of GM food and led to greater overall satisfaction. In contrast, consumers were more receptive and satisfied with GM foods when the FVC actors consistently took supportive stances. This suggested that being anti-GM food was most likely not a stable trait. In addition, the analysis lent support to a general preference for and higher satisfaction under a mandatory labelling regime. From this, it could be concluded that consumer acceptance of GM food would increase under a mandatory labelling regime.

3.4 Paper IV: Genetically modified food and consumer risk responsibility: Effect of regulatory context and risk type on cognitive information processing

Paper IV examined the role of food policy regulations on cognitive information processing and deliberation of consumers' own risk responsibility related to genetically modified (GM) food and whether the effect was dependent on the type of risks. Changes in EU policy regarding biotechnologically modified food have the potential to affect the perception of associated risks among consumers (Wohlers, 2010). With the development of modern food technologies, the concepts of perceived risk and risk responsibility are progressively intertwined (Kermisch, 2012).

The literature has identified self-control and perceived risk as cognitive determinants of risk responsibility. Moreover, cognitive processing has been found to be risk type-specific. Consumers' risk perception of the introduction of GM food can be categorised into four major groups: human health and food safety, environmental, socioeconomic and ethical risks (refer to Frewer et al., 2013; Peterson et al., 2000; Stirling & Mayer, 1999; Straughan, 1999; WHO, 2014). Despite their importance, cognitive elements of information processing and deliberation related to consumers' own risk responsibility are not yet well understood.

Using artefactual field experiment data generated in Sweden, the mediating role of perceived risk and self-control examined on the effect of changes in policies governing GM food on consumers' willingness to attribute risk responsibility to self and weather the effect is moderated by type of the risks. While the results suggested a direct effect of change in policy regimes on perception of risk, the consumers' willingness to assign responsibility to self not being directly linked either to policy context or to risk perception. Instead, personal responsibility was mediated through self-control and moderated by health risks. The results suggested that those consumers who had greater health concerns showed less willingness to assign responsibility to themselves in situations in which the GM product was introduced. The results in this part corroborates the findings of Leikas (2009) indicating self-control as a determinant of personal responsibility judgement with respect to the risks of consuming GM food.

Furthermore, the results verified that less restricted GM policies induced a higher risk perception except socioeconomic risks. Socioeconomic risks play a *de facto* role in real-world decision-making, but as stated by Torgersen (2004) they tend to hide behind health and environmental risk. Consistent with previous studies (e.g. Erdem et al., 2012; Henderson et al., 2010; Leikas et al., 2009; Van Wezemael et al., 2010), the results demonstrated that consumers attributed less responsibility to themselves and instead considered other actors in the food chain (*e.g.* the food industry and regulatory bodies) to be more responsible for food risks. There has been a shift in the societal perspective on the role of consumers in the food chain from being a passive purchaser to being increasingly responsible for self-protection (Fischer et al., 2007). However, with respect to GM food, the findings did not support consumers' willingness to accept responsibility, with them perceiving other actors as being more responsible. Nevertheless, the introduction of GM food raises some concerns about personal responsibility among health-conscious people. The results gave prominence to the need to elucidate guideline recommendations related to the health risks associated with GM foods. This calls for further attention to the health risk issues and the role of consumers' judgment and self-control in the face of these risks in the institutional design of agro-biotechnology.

3.5 Discussion and concluding remarks

This thesis contributes to the area of consumer decision-making and risk perception related to the use of biotechnology in food production. Paper I presents a meta-analysis examining the systematic evidence in existing research on consumers' evaluation of biotechnology in food products. The findings sheds further light on the most influential factors in consumer acceptance of genetically modified (GM) food. The results substantiate the belief that GM food with farm-focused benefits are considered an inferior alternative relative to unmodified food products, but direct consumer benefits were considered more desirable. Papers II-IV examined Swedish consumer behaviour in relation to a

GM food with direct tangible health benefits and indirect environmental benefits. Papers II and III addressed the interdependency in consumer decision-making, with the focus in the latter paper shifting to satisfaction as the outcome of the decision-making process. Paper IV dealt with the effect of GM policy setting on cognitive information processing of risk perception and risk responsibility. The conclusions that can be drawn from Papers I-IV, which contribute to addressing the research gap in this field, are all relevant for GM food policy developments. There are at least four main policy-relevant contributions made by these papers.

First, consumer evaluation of biotechnology is largely insensitive to the type of food product and general benefits of biotechnology. Direct benefits and health-improving features that are built into food products, however, are significantly appreciated. Reviews by Frewer et al. (2013) and De Steur et al. (2014) point out that there have been several empirical studies focusing on agronomic traits and various socioeconomic aspects, while research on the direct product benefits of GM foods is still relatively underrepresented. Furthermore, the results confirm the findings of earlier studies (e.g. Lusk et al., 2005; Lusk et al., 2015; Yue, Zhao, Cummings, & Kuzma, 2015) that consumers' acceptance of GM food largely depends on the perception of certain risks related to the technology in question. Modification of animal genes as well as transgenic gene transfer (i.e. vertical genetic modification) deter consumer acceptance. Hence, gene modification within the same species is generally more appreciated than all other technologies. Consumers showed more concern for safety and health risks associated with gene modification. The ethical and other social concerns play a *de facto* role in real-world decision-making, but as suggested by Torgersen (2004) they tend to hide behind scientific risks.

The second policy-related contribution refers to context dependency in consumers' GM food acceptance and satisfaction. The results suggested that the policy setting in itself works to increase public scepticism towards application of biotechnology in food production. EU consumers' opposition to GM food can partly be related to the risk-based nature of regulations (Torgersen, 2004). Additionally, media representation of food developments using biotechnology have shifted towards a more 'risk-oriented' communication and away from a balanced discourse (Bauer, Kohring, Allansdottir, & Gutteling, 2001; Finucane & Holup, 2005) and this may have contributed to public suspicion and what is referred to as 'the social amplification of risk' (see Finucane & Holup, 2005; Frewer, Miles, & Marsh, 2002; Kasperson & Kasperson, 1996; Pidgeon, Kasperson, & Slovic, 2003). Highly restrictive policies discourage acceptance of GM food. In contrast, less restrictive policies lessen the opposition towards

GM food and increase the level of satisfaction, at least in situations where consumers realise that other actors are benefiting from and supporting the commercialisation of GM food. In fact, the perceived similarity between the stances taken by actors in the food chain increases the likelihood of consideration of choice by consumers, and ultimately increases satisfaction. According to behavioural research and the attraction effect theory (e.g. Lehmann & Pan, 1994), consumers are likely to draw inferences from available information on stances taken by food value chain actors. Previous studies have addressed the contingency and context dependency in decision-making, such as the effects of complexity or time pressure (see for review Ford et al., 1989). In essence, when confronted with complex decision situations, people often simplify (using heuristics) the decision process (Payne, Bettman, & Johnson, 1993). In such cases, contrary to normative theories of preferential choice (see, e.g. Keeney & Raiffa, 1976), the decision process tends to be non-compensatory (Payne et al., 1993; Weasel, 2008) and rather based on heuristics. The extent of similarity or dissimilarity in stances contributes to the cognitive consonance (or dissonance) and hence to the cognitive complexity in the decision-making process (Ong et al., 2017). Moreover, the relativity in consumer acceptance or rejection of GM food arises not only because of the similarity or dissimilarity in other actors' stances, but also because of external social factors. In other words, consumers consider a choice to be more attractive if it is consistent with what others have chosen. Strong evidence was found that among FVC actors, food retailers have more influence in shaping consumers' GM food choice. Retailers play a central role in leading the food industry, generating demand for foods and establishing quality standards (Flynn, Harrison, & Marsden, 1999). Retailers can therefore play a central role in integrating other actors' positions in relation to GM food policies.

Third, the introduction of a mandatory labelling regime for GM foods can be justified due to the high support of consumers. Labelling guarantees consumers' right to choose and increases satisfaction while accepting responsibility for the consequences of choice (Knowles et al., 2007). The results indicate that both pro-GM and anti-GM groups agree on a mandatory labelling scheme (although from different perspectives). This general preference has also been reported in previous studies (e.g. Ekanem & Mafuyai-Ekanem, 2004). This is important since mandatory labelling incurs additional costs (Marchant et al., 2010) which should be considered in the development of new GM products. Furthermore, as indicated in Paper I, consumers are sensitive to increases in GM food prices. Therefore, in addition to the inclusion of direct benefits to consumers in any GM development, the cost effectiveness of labelling also needs to be taken into consideration.

Fourth, the policy context affects consumers' perception of risk and indirectly their personal willingness to take responsibility. For health-conscious consumers, the commercialisation of GM food decreases the perception of controllability of risks and hence the willingness to take personal responsibility. The data obtained are broadly consistent with major trends in which consumers hold policy makers and industry responsible for risks associated with the production of GM food. The personal responsibility judgement for health-related risks would shrink further if GM products were allowed to be commercialised since consumers perceive that they have less control over the risks. It seems that distance (both physical and psychological) from actors in the food chain induces information asymmetry. The information asymmetry will affect the perception of GM risks, which is referred to as quality uncertainty (Emons & Sheldon, 2002). According to McCluskey and Swinnen (2011), food scares can be considered 'dreaded risks' since they are understood by lay people, whereas new food technologies, such as genetically modified foods, and nanotechnology are regarded as 'unknown risks'. Consumers confer responsibility for such unknown risks on other actors since they perceive that they do not have sufficient control over risks (Frewer et al., 2004). The growing importance of public engagement in EU food policy development (Frewer, 2003; Frewer et al., 2014; Stemerding & Rerimassie, 2013) and the close connection between risk and responsibility require a more indepth understanding of the cognitive processes behind GM food risk responsibility.

Building on these findings, the policy context can affect consumers' cognitive perception of risk and responsibility and ultimately their decisions. These results are relevant to actors within the food chain and in particular in policy formation. Nevertheless, there are some additional interesting issues to focus on in future research related to the policy effect on consumers' decision process. One such issue is an analysis of trust of actors and its relationship with risk perception and responsibility attribution (Rousselière & Rousselière, 2010). The intrinsic qualities in food attributes make risk information and communication vital for food acceptance, which itself depends on trust in the source of information (Kjaernes, 2006). The interdependencies with trust among food chain actors and food regulators will provide an understanding that is vital to the institutional design of biotechnology standards (De Krom & Mol, 2010). Furthermore, it could be useful to assess the link between policy context, consumers' personality and acceptance of agri-biotechnology for multifunctional food products (see Bermúdez, 1999). In conclusion, there are still areas related to the context effect and interdependency in consumer's decision-making around GM food that would be interesting to analyse from a policy perspective in order to fill the research gap.

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Acknowledgements

After five amazing years, I am really thrilled to reach the end of this phase of my life. I could not have achieved this without the support of others. I would like to express my gratitude to the people who in various ways have helped and inspired me throughout my studies.

First and foremost, I would like to express my special appreciation and thanks to my supervisor, Professor Carl Johan Lagerkvist, for his outstanding supervision and excellent mentorship. I would like to thank you for supporting my research and directing me to grow as a researcher. I appreciate your high-quality guidance and high ambitions mixed with your kind attitude. Your advice on both my research and my career has been priceless. I would also like to thank my co-supervisors in the first year, Professor Sebastian Hess and Professor Joachim Scholderer, for their constructive feedback and guidance in conducting the meta-analysis project presented in Paper I. Special recognition goes to my co-author, Dr. Brandon McFadden, for his insightful and detailed comments on Paper II. Furthermore, I would like to thank Dr. Mikael Andersson Franko for his advice on the statistical analysis in Papers II and III. Furthermore, I am grateful to Mary McAfee for her language editing of the manuscripts. I am also grateful to Associate Professor Cecilia Mark-Herbert for her encouragement and support to keep up with my studies.

My gratitude is also extended to Professor Rodolfo Nayga Jr. I am grateful that you agreed to be the opponent in my final seminar. I would also like to thank the evaluation committee: Professor Frode Alfnes, Assistant Professor Linda Thunstrom, Dr. Hans De Steur and Professor Yves Surry. Thank you for making my defence a pleasant experience and for your excellent comments and suggestions.

I am indebted to Dr. Ali Yavari for his technical input in the programming and development of a computer-based instrument for the data collection. I also had the pleasure of working with and getting input from William Redekop, Andreea Bolos, Olivier Butkowski, and Bisrat Misganaw – thank you. I appreciate the efforts and support from my research assistants (Victoria Agyepong, Louise Åhlman, Viktoria Lagerkvist, Maryam Ghorbankhan etc.) during the data collection periods that provided me with such rich data. In addition, special thanks must be given to the staff of Uppsala University who prepared the computer labs for my data collection. Thank you also to my nice colleagues and staff at the Department of Economics, SLU for your support and encouragement during these years. I have greatly benefited from the insights and fruitful discussions I have had with the Decision-Making and Managerial Behaviour research group. I would particularly to thank Helena Hansson, Gordana Manevska Tasevska and Nina Lind for their brilliant comments and feedback on my manuscripts. I am also grateful to Micaela M. Kulesz for her immense help in Latex coding and valuable comments on my papers. I also want to briefly but profoundly thank my fellow doctoral students: Abenezer, Annie, Amiable, Chrysa, Franklin, Hanna, Julian, Jonathan, Katarina, Lovisa, Maria, Suvi, Tobias, Uliana, Wondmagegn etc. You all made this possible! I am so very thankful for all your comments, criticisms and discussions which kept me going.

Last but not least, a special thanks to my dear family and friends for all your support. Words cannot express how grateful I am to my parents, my sister Shahrzad and my brother Arash for all of the sacrifices you have made on my behalf. Your wishes for me were what sustained me thus far. Warm thanks go to all of my friends who have supported me in my research journey and motivated me to strive towards my goal. Lastly I would like express my appreciation to my beloved wife Baharak who spent sleepless nights with me and was always my support in the moments when there was no one to answer my queries. To conclude, I would like to express my deepest appreciation to everyone who participated in the study, in particular the residents of Uppsala.