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„Agricultural Biotechnology in East Asia:

A comparative assessment of GM crop adoption in China and Japan"

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List of Abbreviations

AA	asynchronous approval
AAAS	American Association for the Advancement of Science
ABDC	Agricultural Biotechnologies in Development Countries
AECEN	Asian Environmental Compliance and Enforcement Network
AF	Analytical Framework
agri-	agricultural
agri-biotech	agricultural biotechnology
AQSIQ	General Administration of Quality Supervision, Inspection and Quarantine of China
BCH	Biosafety Clearing House
biotech	biotechnology
Bt	Bacillus thuringiensis
CAA	Consumer Affairs Agency
CAC	Codex Alimentarius Commission
CAS	Chinese Academy of Science
CBD	Convention on Biological Diversity
CCPC	Chinese Communist Party Committees
CPB	Cartagena Protocol on Biosafety
CPC	Communist Party of China
CPD	Central Propaganda Department
CPPCC	Chinese People's Political Consultative Conference
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CRWLG	Central Rural Work Leading Group
CSTI	Council for Science, Technology and Innovation
CSTP	Council for Science and Technology Policy
CTA	Technical Centre for Agricultural and Rural Cooperation
CUJ	Consumer Union of Japan
DNA	deoxyribonucleic acid
ESEB	European GMO Socio-Economics Bureau
EU	European Union
FAO	Food and Agriculture Organization
FAS	Foreign Agricultural Service

FDA	Food and Drug Administration
FSCJ	Food Safety Commission of Japan
FTE	full-time equivalent
GAIN	Global Agricultural Information Network
GDP	Gross Domestic Product
GE	Genetically Engineered
GERD	gross domestic expenditure on R&D
GM	genetically modified
GMO	Genetically Modified Organisms
GOJ	Government of Japan
HC	headcount
HT	herbicide-tolerant
IFOAM	International Federation of Organic Movements
IGES	Institute for Global Environmental Strategies
IP	identity preservation
IPC	Integrated Food Security Phase Classification
IR	insect-resistant
ISAAA	International Service for the Acquisition of Agri-Biotech Applicatio
ITC	International Trade Centre
JAS	Japan Agricultural Standard
JCCU	Japanese Consumers' Co-operative Union
JICA	Japanese International Cooperation Agency
JMC	Joint Ministerial Conference
LDP	Liberal Democratic Party of Japan
LLP	Low Level Presence
LMO	living modified organisms
MAFF	Ministry of Agriculture, Forestry and Fishery
MEE	Ministry of Ecology and Environment
MEP	Ministry of Environment Protection
METI	Ministry of Energy Trade and Industry
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MHLW	Ministry of Health, Labour and Welfare
MIC	Ministry of Internal Affairs and Communications
MOA	Ministry of Agriculture and Rural Affairs of the People's Republic

	of the People's Republic of China
MOE	Ministry of Environment
MOFCOM	Ministry of Commerce
MOH	Ministry of Health
MOST	Ministry of Science and Technology of the People's Republic of China
n.a.	not available
NARO	National Agriculture and Food Research Organization
NBC	National Biosafety Committee
NBSC	National Bureau of Statistics of China
NCGC	National Center for GM Crops
NDRC	National Development and Reform Commission
NGO	Non-Governmental Organizations
NHFPC	National Health and Family Planning Commission
NHK	Nippon Hōsō Kyōkai
NIAS	National Institute of Agrobiological Sciences
NIES	National Institute for Environmental Studies
NTC	National Technical Council
OBA	Office for Biosafety administration of Agricultural GMOs
OECD	Organization for Economic Co-operation and Development
OF	organic farming
PPP$	Purchasing Power Parity dollars
RMB	Renminbi
S&T	Science and Technology
SCBD	Secretariat of the Convention on Biological Diversity
SIP	Cross-ministerial Strategic Innovation Promotion Program
STS	Science and Technology in Society
TV	television
UIS	UNESCO Institute for Statistics
UK	United Kingdom
UN	United Nations
UNESCO	UNESCO Institute for Statistics
US	United States
USDA	United States Department of Agriculture

VAD	Vitamin A Deficiency
WHO	World Health Organization
WTO	World Trade Organization

1. Introduction

1.1. Relevance of research

Food belongs to one of the most basic human needs, and the importance of the availability of a sufficient amount of food at all times remains a high priority. However, with a continuously climbing population, the global food system is being subjected to increasing challenges from multiple perspectives. Malnutrition and hunger continue to poise as persistent threats in several parts of the world. In 2019 there were 690 million people chronically undernourished, a slowly rising number with 60 million additional hungry people since 2014 (FAO et al. 2020, viii). According to the FAO, the world population will have grown by 2050 to 10 billion people, which will increase global demand for agricultural products by 50 percent over the current produced amount. The global dietary transition caused more people switching to large amounts of meat, fruits, vegetables, and processed food for consumption, which adds to existing stresses on natural resources. While growing large-scale plant food comes with deforestation and land degradation, the meat production leads to crucial consequences, such as higher greenhouse gas emissions (FAO 2017a, xi). In order to meet increasing food demand, new ways of growing food are needed. To this end, biotechnology has proven itself to be a reliable option over the past years (Rettner 2013). Considering the role of genetic modification (GM) in mitigating the abovementioned challenges, while offering a solution to current and future food problems, this thesis will focus on GM crop adoption in China and Japan.

The world's current food supply chain is under heavy criticism for its inefficiency, causing one-third of available food to be wasted. However, one of the reasons for GM biotechnology opponents refusing to acknowledge its relevance is the belief that by prioritizing advancement of distribution efficiency and making use of the food waste saved from inefficiency alone would be sufficient to cover food demand (Ghosh et al. 2016, 2). One of the most quoted estimations states that "as much as half of all food grown is lost or wasted before and after it reaches the consumer" (Parfitt et al. 2010, 3065). Mismanagement and food losses are indeed crucial issues, especially in developing countries (Bajaj 2012). However, even though dealing with food wastages and losses would save a substantial amount of food, it is no substitution for the necessity of increasing food production in the long run. Sustainable solutions for food production can reduce food waste and loss by limiting casualties early in the food supply chain at the harvest level (Parfitt et al. 2010, 3079). According to Alexander et al., food losses are the highest before harvest, which is an issue that can be solved by improving food production efficiency and food quality (2017, 190).

In 2011 both industrialized and developing countries shared the same amount of wasted and lost food per year (Provost 2011). Nevertheless, they differ in the origins of their food wastes and losses. Developed countries act more carelessly at the consumer level, while poor consumers from countries with lower incomes can simply not afford this kind of wastes. However, food losses can still be found in developing countries, due to their weak infrastructure, including inadequate methods to keep their food fresh such as facilities for storing, processing, and packaging (FAO 2011b, 1). It is worth noting that there is a difference between the terms of “food losses” and “food wastes.” While the prior refers to losses made unintentionally due to inadequate equipment and infrastructure, the latter deals with foods thrown away by consumers, who have acquired more than they need, or retailers, who reject food that does not meet their aesthetic requirements (Lyons et al. 2015). Key solutions for avoiding food wastes and losses involve strengthening food supply chains. This includes increasing attention towards the before mentioned factors such as infrastructure, transportation, as well as storage, processing and packaging. In developed countries, Provost suggests decreasing reliance on retailers such as big supermarkets. Direct sales of farm products to consumers are being encouraged as well as cooperation between retailers and charities for more efficiency of redistributing food that is expired but still edible (Provost 2011).

By improving the efficiency of production methods of key food commodities, food prices can be kept at a steady level or even reduced by keeping competition at bay, thus allowing more people to access them. According to FAO, “food production must clearly increase significantly to meet the future demands of an increasing and more affluent world population” (FAO 2011b, vi). A study from Gustavsson et al. has concluded that around a third of food loss occurs at the production already (2011, v). In the face of these challenges within the food supply chain, agricultural biotechnology (agri-biotech) will remain one of the primary tools for humankind to feed a growing population. Within agri-biotech, GM biotechnology offers a cost-effective agricultural solution which can produce nutritious food efficiently while decreasing food losses on the production level (Azadi and Ho 2010, 165).

GM crops are currently an essential part of the pursuit of sustainable methods to enhance crop productivity. Through agri-biotech crops with stronger biological defenses can be created.

Currently, there are plants available that are resistant to drought, pH, frost, and salt. This means that GM biotechnology can substitute many expensive chemical treatments in order to reach certain tolerance, resistance, and slow ripening (Azadi and Ho 2010, 165). Especially in the case of soybeans, GM biotechnology can reduce the input of both chemicals and labor (ibid. 161). GM technology can also improve the nutritional value of crops. One of the examples is the "Golden Rice," which has been used to tackle the issue of 190 million preschool children who suffer from Vitamin A Deficiency (VAD) every year (WHO, 2017).

According to Adenle, GM crops benefits exceed sustainable food production by encompassing “socio-economic, environmental and human health benefits” (2011, 83). Especially small-scale farmers can directly profit from GM crops adoption since the enhanced resistance of GM crops can increase their revenues. During the past 20 years of GM crop commercialization, 18 million farmers benefitted from GM crop adoption. Next to economic advantages, farmers also benefit from the decrease of insecticide usage, thus helping them to lower their exposure to these chemicals. Less insecticide application also contributes to environmental sustainability (James 2015, 6). Therefore, its relevance is exceptionally high in developing countries and seen as a key solution in achieving food security (Ruane and Sonnino 2011, 356). With higher efficiency provided by GM biotechnology, production costs can be lowered while outputs are increased simultaneously. These lead to a reduction in supply prices, which grants more people access to food products (Chatterjee et al. 2016, 389).

GM biotechnology contributes to sustainability and environment protection, which are two increasingly relevant global topics. The application of GM biotechnology in crop farming indirectly reduces the effects of climate change stresses. In terms of sustainability, GM biotechnology enables a strategy known as "sustainable intensification," which describes the enhancement of crop productivity without the need to increase already used global cropland. Therefore, this strategy also preserves biodiversity by limiting crop-farming areas to a minimum. By raising the productivity and efficiency of crop farming, the environment can be relieved from additional stresses caused by potential deforestation for more cropland. For the very same area that has been used for the cultivation of non-GM crops, GM crops instead can achieve higher revenues, thus allowing the strategy of sustainable intensification to preserve agricultural biodiversity (James 2015, 12). Therefore, not only crop yields can be increased, but also plant varieties and animal populations.

Apart from the advantages that come with GM crops, GMOs in food are still a controversial topic and thus remain a heavily disputed subject even twenty years after its commercialization due to their widespread usage. Controversies date back to the 1980s when GMOs were first used in medical products (Azadi and Ho 2010, 160). According to the World Health Organization (WHO), nowadays, consumers are more receptive towards biotechnology's use in medicine than in food. Usage for the benefits of "vaccines, medicines with improved treatment potential or increased safety" gains much easier acceptance (2014). Discussions have been even more intense in the face of releasing GM crops for agricultural usage. Disputes occur nowadays between scientists, stakeholders, and other experts, with the main critics among politicians, environmentalists, and scientists. Loud voices can also be found among "organic farmers, consumers and health advocacy groups, public interest groups, trade protectionists, grain importers, religious rights groups and ethicists" (ibid., 162).

Concerns about potential risks to environmental and health safety have kept GM crops continuously in the spotlight. Ironically, both topics are also among the ones that are used by GM proponents for promoting biotechnology. For example, while GM biotechnology can reduce pesticide, in the case of GM cotton, it also has the potential to cause a rise of secondary pests. This could cause unforeseen ecological changes and disrupt the earlier mentioned biodiversity preservation, which should have been one of the advantages of GM crop adoption (Gabol et al. 2012, 2810). Many concerns involving GM crops are two-pronged. One of the much-distributed benefits that GM crops can induce is herbicide tolerance, more specifically, tolerance against glyphosate. On the one hand, herbicide-tolerant crops caused a rising application of glyphosate, which is indeed a toxic herbicide and, according to the World Health Organization (WHO) classified in Group III as "slightly hazardous" (WHO 2010, 71). On the other hand, glyphosate belongs to the group of comparatively less hazardous herbicides and have substituted previous combined use of several herbicides from more hazardous groups (Burachik 2010, 589).

Apart from the involving disputes, GM products are currently vastly widespread, reaching even beyond our food supply chain and therefore remains a topic that needs to be paid close attention to, despite or even because of the rising controversial debates. The topic of GM foods has become more relevant nowadays, considering its definition alone, which includes all products that incorporate any kind of GM ingredient. For example, products that are made by using GM microorganisms, such as GM papaya and cheese, also belong to them. The same applies for soybean oil, which is processed from GM soybean. GM products are widely represented in feed for farm animals as well. Soybean meal is recognized as an efficient protein feed and emerges as a by-product when processing soybean. In the human food sector, soybean powder is also accepted for its high protein content and, therefore, regularly used as a substitution for meat. Another potential GM derivate is cornstarch developed from GM corn, one of the most planted GM crops. Cornstarch becomes the perfect example for how easy it can be to find traces of GM products in food since cornstarch syrup alone can be used in a wide range of food varieties, such the production of "candies, pastry, bread, jam and beverage" (Kou et al. 2015, 2158). In recent years, GM microorganisms are also regularly used for the production of yogurt and cheese (Wong and Chan 2016, 124).

Considering GM biotechnology's wide role in our lives, its emergence and advancement are comparatively recent events. According to Smyth, the first commercial GM crops were produced in China in 1992, involving transgenic tobacco for the advancement of seed development (2014, 195). The following milestone achievement for GM biotechnology occurred when the US approved for the very first time a GM crop variety, more specifically GM tomatoes, for human consumption in 1994. Both Canada and the US invested in research and approval of additional commercial GM crops such as transgenic "varieties of canola, corn, cotton and soybeans." The approval for GM animal for human consumption occurred just a few years ago in 2015 and was also led by the US. However, the majority of GM foods are still produced primarily based on GM plants with the cultivation of GM crops increasing continuously (Wong and Chan 2016, 124). East Asia has been involved with GM crops since the 1990s, similar to the North American pioneer countries. In this thesis, the examined country cases in the empirical part involve China and Japan (ibid.).

Although China and Japan's population vary vastly in their sizes, they share similar cultural heritage and mentality reflected in the media and politicians. However, apart from both East Asian countries sharing similar cultural norms, their discrepancies in economic development and politics are among the factors that are expected to lead to variations in their choices for problem-solving (Lin and Yi 2013, 298). Therefore, this research aims, among others, to gain an understanding of how similarly or differently the respective stakeholders of each country act in order to advance the agricultural sector through biotechnology. This thesis is conducted not only in the interest of the agricultural sector but also in other related or similar industries that could be enhanced by the application of agri-biotech as well. An analysis of the policies and regulations involving agri-biotech and its products becomes rising important due to their increasing use and close relation to trade.

A comparative assessment of China and Japan is expected to unfold insights on several issues. In terms of analysis, it would reveal the sources for the smoothness and difficulties in each respective adoption while using the AF and the alternative country case as a benchmark for orientation and comparison. On the one hand, both nations show similarities in their demand for GM crops, due to their finite domestic natural resources and limited self-sufficiency, rendering a comparative analysis feasible. Both countries have deficiencies in arable land area and are therefore dependent on import of the products they cannot sufficiently plant themselves. On the other hand, I expect to discover differences nonetheless in their approaches towards the needed commodities, which could reflect their behavior on similar subjects and even assist in making predictions for future developments, such as the likelihood of further introductions of new GM crops varieties. Through the comparative assessment of China and Japan, I would also like to elaborate on their efficiency or inefficiency of GM crop adoption by comparing the process of their actual adoption, expecting to find the reasons for this issue primarily in the regulatory factors. Regulations are crucial tools that not only enable the execution of any newly introduced policy but can also show the different preferences of stakeholders in each country (Vigani and Olper 2013, 32).

The outcomes of vital regulatory aspects for a successful adoption can be relevant for other international adopters and competitors as well. Especially when it comes to trade, it is crucial for exporters to heed each importing nation's specific and current regulatory rules to avoid unnecessary losses. By analyzing the policies and regulations of biotech crops, the trade flow of these commodities can be explained (Ma et al. 2017, 460). This understanding is important for agricultural exporters, especially when it involves major agricultural food markets, such as China and Japan. These two influential nations can directly impact the international trade of not only GM food products but also conventional foods with their regulations and policies. Due to the size and importance of both East Asian countries' economies, they have the potential to influence their neighboring nations (Armstrong 2012, 1102). Mabaya et al. witnessed such phenomena in the form of leading nations establishing precedents, which can then be mimicked in fellow countries (2015, 582).

The findings would not only be relevant for GM crops but ideally also provide some insights into both countries' approaches to similar commodities and adopted technologies. Even though this comparative assessment is mainly conducted from a historical perspective of the relevant factors since GM crop adoptions are already in order, it has the potential to provide insights on the future development of GM crops and biotechnology in East Asia. The general controversial nature of the subject of GM biotechnology, residing in both nations' populations but expressed and confronted individually, is expected to deliver this comparative assessment with not only additional challenges but also stimuli.

1.2. Research questions and research objectives

The guiding research question of this thesis is as follows:

What are the similarities and differences between GM crop adoption in China and Japan?

A comparative analysis of China and Japan's approach to GM biotechnology and the assessment of their individual GM crop adoptions are expected to offer insights into the technology and its products' roles in each East Asian country. Biotechnology has reached the prime of its development in recent years, with GM being the fastest adopted crop technology worldwide (James 2015, 4). GM biotechnology for crops has come a long way since its commercialization in 1996. A comparative analysis can reveal East Asian approaches to agri-biotech, which has become a tool that will keep refining and growing on global relevance. Currently, GM biotechnology has already established itself beyond merely our food supply system, but also through GM cotton in the textile industry (Wong and Chan 2016, 124) and the medical sector (WHO 2014; Dutta 2016, 509).

Since the main topic of this thesis involves the adoption of GM crops, this research is conducted primarily from a historical perspective. The focus will be put on the influential factors and more recent developments on the subject. However, in the process of accumulating data, occasionally predictions of the future relevance of GM biotechnology within China and Japan can be revealed based on secondary literature and each country's trajectory of agri-biotech development. Not only similarities and differences will be aimed to be found and analyzed, but also strengths and weaknesses of each country's way of GM crop adoption based on cases of other experienced GM biotechnology adopting nations.

Considering China's high population but limited arable land, it is understandable that the country has been making considerable investments in agri-biotech, not only for its research but also use of GM crops (Kou 2015, 2157). This development was only possible with strong government support which enabled encouraging environment concerning its advancement. The commercialization of the Bt cotton opened up new opportunities for China, that were not accessible for other developing nations without timely investments in the same field (Cao 2018, 178). Among crop varieties, China has made progress, especially in terms of insect-resistant GM rice development. After having promoted GM biotechnology for over 20 years, China belongs among the countries with much experience and has a highly developed regulatory system for managing GM crops (Li et al. 2014, 565).

Japan also belongs to one of the biggest GM food and feed importer in the world, and its increasing reliance on food imports remains a major concern for its government (Croft 2016). With very limited arable land, Japan is heavily dependent on its import resources from around the world, especially in terms of food crops, such as corn, soybean, and canola. The government of Japan (GOJ) acknowledged the shortage in one of its Science and Technology Basic Plans and appealed urgently to secure stable food supplies by assessing crop suitability and reducing dependency on foreign suppliers with the help of science and technology (S&T) (Cabinet Office, GOJ 2016, 21). Therefore, the circumstance around agriculture is strained, especially considering the imbalanced ratio in its supply and demand for agricultural products (MAFF 2015, 4). A lot of these food commodities are currently produced with the help of biotechnology. With the US being Japan's renowned supplier, Japan is receiving most of the needed corn import from one of the biggest GM crops producing nation. In recent years, there has been some shifting in suppliers for Japan towards South America; however, the US remains one of the most important food producers and distributors for East Asia, especially Japan (Sato 2016, 2).

1.3. Methodology

Even though the literature on biotechnology and GMOs, in general, are vastly represented, an analytical framework (AF) designed explicitly for the topic of this thesis does not yet exist. Available works of research on GM biotechnology and its products are carried out either in a broad manner or on very narrow and specific topics. At the time this research was conducted, a theory or AF for comparative analysis of GM crops adoption in East Asian countries was not available then. Therefore, I have compiled my own framework for this thesis based on studies from more field experienced peer researchers. In the course of literature research for this thesis, I have encountered several relevant studies and ultimately selected three of them to be used as core literature and main pillars for my customized AF.

The AF is structured in two main sections. The first section focuses on the political and socio-economic factors that induced the adoption of GM crops, while the second section deals with the regulatory factors. The first section is primarily derived from Mabaya et al.'s research on the political and socio-economic key factors during GM crops adoption (2015) and complemented with Burachik's research on Argentina's GM crop adoption (2010), where the author dealt with the necessary circumstances and conditions for introducing new biotechnology into Argentina and critically assessed the impact of GM crop adoption on the country (ibid.). The second section follows Vigani and Olper's index of regulatory components for GMOs (2013). The choice of regulatory factors that are treated in this thesis is based on this third core literature.

The empirical research is conducted in a qualitative form based on the works from peers in a similar field. Primary literature was used as much as possible, although secondary literature represented the majority of the sources. The goal of this thesis is to comparatively analyze the influential factors in GM crop adoption in China and Japan using an AF. In the process of assembling the composite framework, the relevant influential factors for GM crop adoption in a country were determined based on peer studies. In order to accomplish the comparative assessment, information of the relevant factors in each country case needed to be first individually extracted first and then comparatively analyzed once sufficient findings were accumulated.

2. Literature Review on GM crop adoption and State of the Art

2.1. Terms and definitions

There are currently three options for crop production in agriculture –organic, traditional, and GM products. Organic farming produces crops "without fertilizers, chemical pesticides, irradiation or genetic engineering." The application of natural pesticides and fertilizers is prevalent for this farming method, although specifically approved synthetic products are also allowed when natural alternatives are not sufficient. Conventional crops are usually produced in a single high-yield fashion. These high yields can be achieved by applying technological innovations and the application of synthetic pesticides and fertilizers. Conventional farming produces food in higher quantity while requiring less land than organic farming, which again results in more affordable food products (Cochran 2016). Nevertheless, under the beforementioned challenges, the ability of conventional and organic farming to feed the world is becoming increasingly insufficient, especially considering aspects such as production efficiency and on-time deliveries. Along with the advancement of agricultural technology, more efficient solutions than conventional farming methods became available with GM products among them. However, GM products tend to have a bad reputation, with many consumers believing them to be dangerous, while organic crops are often being held as the healthier choice (Bodiguel 2016, 263).

The term "biotechnology" in general covers a broad scope of various technological measures that can be used in many different areas. The FAO defines biotechnology as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use" (CBD 2017). "Agricultural biotechnology" again encompasses various technological methods that, more specifically, can be utilized in food and agriculture. Within that scope again, one of the most promising but also controverted subjects of agricultural biotechnology is "genetic modification" (GM) or "genetic engineering" (GE) along with the products resulting from this method, known as "genetically modified organisms" (GMOs) (FAO 2018; ISAAA 2018b).

The technology of GM can be best described in comparison with the conventional plant breeding method. All plant breeding methods' goal is to develop plants that provide excellent agronomic characteristics. Conventional plant breeding cannot guarantee the result of specific gene combinations after the crossing. Both desirable, as well as undesirable genes, can be imparted during the breeding. A desired trait can also be lost during this process since both parent plants' genes are comingled and randomly imparted to the next generation. On the other hand, GM can offer a direct transfer of specific genes in order to gain a favorable trait. It is also worth noting that crops can also be genetically modified "by removing or switching off their own particular genes." Not every GM technique necessarily has to involve the insertion of genes from other organisms (ISAAA 2018b).

Since its commercialization, GM biotechnology has continuously produced new ways to increase crop varieties with higher yield and less need for additional inputs, such as fertilizers or pesticides. These are some of the advantages that can specifically be provided by GM biotechnology used on crops, which are primarily referred to as "GM crops" but also known as "biotech crops," "transgenic crops" or "GE crops" (James 2015, 1; Adenle 2011, 84). Two other reoccurring terms in this thesis are "GM trait" and "GM event." While the former is the raw phenotypic characteristic of a gene, the latter refers to a product of the process in which a GM trait has been inserted into a plant genome. Not only a single trait can be inserted, but also multiple genes. Therefore, one single GM event can have more than one GM trait. A GM crop can again encompass one or more GM events and, thus, phenotypically carry at least one GM trait (Pilacinski et al. 2011, 2).

One of the main goals of GMOs in agriculture is to enhance productivity while maintaining natural resources by genetically improving plants or diagnosing plant diseases (Ruane and Sonnino 2011, 356; Cochran 2016). The capability of increasing productivity is an important advantage that GM biotechnology brings along since agriculture nowadays has only a limited amount of land and water resources available for further expansions. Under these limited circumstances in natural resources, rising food demand should be met increasingly through agricultural technologies that enable higher productivity and efficiency in resource-usage (FAO 2017b). When it comes to agricultural biotechnology's capacity to face food deficit and environmental challenges, its strength lies primarily in the agricultural sectors of "crops, forestry, livestock, fisheries and agro-industry" (FAO 2011a). The focus of this thesis will be solely on GM crops and their adoption in China and Japan.

One of biotechnology's objectives in food production is to increase its growth by "increased yield per unit of land," so no further landmasses are needed to gain more food (Ruane and

Sonnino 2011, 356). GM crops have been commercialized since 1996, which made the year of 2015 the 20th anniversary of the global commercialization of GM crops. By 2015 there were 2 billion hectares of transgenic crops being grown. Half of them belong to GM soybean, and the other half consists of 0.6 billion hectares of GM maize, 0.3 billion hectares GM cotton, and 0.1 billion hectares GM canola (James 2015, 1). There are also other breeding technologies that the global scientific community has been researching, the most promising one being new crop biotechnology called "genome editing" or "gene editing." While research on them is promising and would allow high precision and editing plant genes, currently, GM biotechnology remains the most effective and widely used biotechnology for advancements in agriculture (James 2015, 14). The topic of this thesis covers the initial process of the adoption phase of GM crops, which in general refers to both the cultivation as well as the import of GM crops. A country's demand for GM crop adoption depends on its designated use, such as food, feed, or clothing (Aldemita et al. 2015, 151).

2.2. Contributions by international organizations

Essential contributions to GM crop adoptions on a global scale can be found in the works of international institutions, such as the FAO under the United Nations (UN) and the European GMO Socio-Economics Bureau (ESEB) under the European Commission. Two milestone agreements are the Codex Alimentarius and the Cartagena Protocol on Biosafety (CPB). Those are considered the most widespread and well-developed international agreements (Vigani and Olper 2013, 34). The Codex Alimentarius represents a collection of food safety standards relevant for the protection of consumer's health and fair-trading relationships (FAO/WHO 2018a). The CPB offers guidelines for safe ways of handling, transportation, and utilization of GMOs (SCBD 2000, 3). Both are also part of this thesis' analytical framework and will be explained in detail in the theoretical part.

Kathage et al. composed a reference document for the ESEB that provided a list of relevant topics on GM crops cultivation, including indicators and methods. The main objective of this document is to offer a method to scientifically assess socio-economic impacts in EU member states by considering different segments of society, such as people in the crop farming sector and those outside of it (2015, 7). Even though their research scope covers impacts within the EU primarily, many of them are also relevant in non-EU countries.

Generally, many reports on biotechnology and GM crops from international institutions tend to focus on food and nutrition security, both being considered two of GM food crops' main contributions to humankind. The International Service for the Acquisition of Agri-Biotech Applications (ISAAA) is a non-profit organization that offers an international platform for sharing and disseminating scientific data on crop biotechnology to the global community. It also offers support at transferring these technologies from public-private partnerships to developing countries (ISAAA 2018a). James Clive published within the ISAAA a brief on GM crops and their role in global food security and sustainability in agriculture (2015). One of the most recent briefs was released from the ISAAA in 2018, focusing on the current situation of commercialized GM crops worldwide.

2.3. GM crops and food security

Outside of international institutions, the availability of literature on GM biotechnology's impacts on food security is even higher and more diverse. According to Azadi and Ho, GM technology has the ability to provide future food security while offering commodities that are more nutritious, affordable, and stable (2010, 161). Qaim dealt with the benefits that GM crops can offer the poor, including raising household income and improving nutrition and health (2010). Ruane and Sonnino devoted their paper to the possibilities of agricultural biotechnologies' contribution to food security in developing countries (2011). They advocated for farmers to receive broader access to technological alternatives and see, especially in agricultural biotechnology, a way to raise productivity while preserving natural resources. The authors also reviewed a report of the FAO international technical conference on Agricultural Biotechnologies in Development Countries (ABDC-10), held in 2010. This document provides an overview of available biotechnological methods that improve productivity while protecting the environment and explains their importance in developing countries (ibid., 361).

Laxman and Ansari provided in their article a discussion on agricultural biotechnology's impact in developing countries and trade while also handling the contributions from sustainability and the environment to food security. However, recently these benefits have become topics of discussions while simultaneously considering the controversies involving the very same topics. Even though the authors have not yet discovered scientific evidence that commercial GM crop production is actively causing environmental harm, they caution against long-term and cumulative effects (Laxman and Ansari 2011, 286). Adenle similarly assessed GM biotechnology's impact in developing countries by discussing both its benefits as well as constraints of GM crops, including the controversial debates (2011). The author sees excellent potential in GM crops and its capability of contributing to sustainable agriculture (ibid., 93). Delaney's research had a more specific focus on the safety assessment of GM crops in developing countries, and the author concluded that there is no evidence of the adverse effects of using biotechnology as a tool in agriculture (2015, 139). The issue of food safety is thoroughly researched based on the broad availability of literature on this topic (Tritscher et al. 2013; Delaney 2015; Laxman and Ansari 2011).

2.4. Effects beyond food provision

The literature on GM biotechnology and GM crops go beyond food security and reach into more extended areas, such as the environmental and economic fields. Especially GM biotechnology supporters believe that GM crops can achieve contributions to sustainability, environment, and climate change (James 2015, 12). In the face of 20 years of commercial production in 2015, Smyth et al. devoted themselves to illustrating the economic, environmental, and health benefits of GM crop adoption (2015). Similarly, Tsatsakis et al. focused primarily on GM food and feed's impact on the environment and health (2017). Even though the authors conceded that GM foods' potential risks to biodiversity cannot be completely ruled out, they generally remain hopeful regarding GM biotechnology's positive impacts, as long as adequate scientific information is provided and risks are examined prior to release (ibid., 118). According to the FAO, the key to sustainable agricultural growth can be reached by increasing the efficient use of land, labor, and other factors such as technological progress, among others (2017, 48). Fan et al. dealt in their research with agricultural biotechnology's role in advancing crop productivity as well as resource use efficiency. Both improvements would not only ensure food security but also believed to enhance environmental quality (2012).

There is also literature available comparing GM crops with products originated from organic farming (OF). Azadi and Ho compared in their research the advantages and disadvantages of GM crops and OF (2010). Rótolo et al.'s study concentrated on the three farming methods of traditional, conventional, and GM-based cropping systems and offers an environmental assessment of these crop production systems (2015). Since this thesis focuses on GM food crops, OF will only be mentioned for the sake of completeness to provide a holistic view of alternative crop options.

On the one hand, GM crops are renowned and praised for their agricultural productivity (James 2015; Raman 2017; Raven 2014; Paul et al. 2018), but on the other hand, also criticized from the socio-economic and environmental perspective (Leguizamón 2014; Rótolo et al. 2015; Arcieri 2016; Tsatsaki et al. 2017). Paramount examples are GM corn with increased yields and GM soybean for needing fewer chemicals and labor in order to harvest. Azadi and Ho discovered that the view on GM technology applications varies amongst different stakeholders. For example, companies applying it stand firmly behind biotechnology's claim promoting food security by providing healthier and cheaper crops. However, at the same time, they are also criticized for being not reliable in the fight for future food security since their main objective lies "in the business of making money, not feeding people" (Azadi and Ho 2010, 161).

2.5. Controversial debates

It is not unprecedented for GM biotechnology and its products to be involved in controversial debates. Upon literature research, it can be concluded that these debates, especially on GM crops, started over a decade ago and remain relevant today. Debates concerning the application of gene technology date back to the 1980s, when GMOs were first used for the production of medications only (Azadi and Ho 2010, 160). Nevertheless, scientific works that deal with the controversies and downsides of GM biotechnology generally provide a comprehensive review on the subject nonetheless and do not entirely dismiss the benefits the technology has brought humankind. There is also a general tendency that researchers from the field of natural science tend to advocate for biotechnology, while the scholars' opinions from the field of social science are more diverse. According to Bodiguel, the majority of scientific community refrained from making radical conclusions, especially in discussions about which agricultural method would be the most suitable in the long run (2016, 263).

Many kinds of literature treating both the benefits as well as the constraints of GM biotechnology and GM crop adoption are available. Adenle, covering both sides of the coin, concluded from her research on the commercial production of GM crops that great potential lies in GM biotechnology's role in sustainable agriculture, especially in developing countries (2011). Zhang et al. provided a critical review of GM foods' both promises and problems (2016). The authors compared the potential consequences of GM crop adoption with the outcomes of technological development advancements throughout history, such as the industrial revolution on the one hand and global warming on the other. Based on similar examples, Zhang et al. argued that ignoring GM crops' potential risks would be equally scientifically unwise as dismissing the benefits and consequences industrialization had brought us (ibid., 122). The research from Gabol et al. similarly treated both the advantages and disadvantages of GM products, including the challenges that come with GMOs' usage. The authors agreed that GM crops can complement but not substitute traditional crops. For safety reasons, they emphasized the importance of risk assessment before introducing GM crops (2012). While Raman dealt in his paper with specific cases of GM crop controversies from the past, the scholar remained optimistic towards the technology's positive contribution towards commercial agriculture in the future (2017, 200).

Uncertainty also occurs in GM plants' environmental effects, which is also one aspect that GM technology opponents heavily criticize next to consequences for consumers and farmers. Especially effects of pest-resistant crops are rather controversial and often accompanied by discussions of concerns about biodiversity. If GM plants cause natural plants to become extinct, they could lead to environmental risks causing consequences that could affect not only agriculture but also the ecosystem and human health (Azadi and Ho 2010). Several works of literature are available on these uncertainties about environmental effects (Leguizamón 2015; Rótolo et al. 2015; Arcieri 2016; Zhang et al. 2016). For example, Zhang et al. devoted a section of their research specifically to ecological risks associated with GM products, including topics such as GM crop's potential of disrupting food webs and resistance to antibiotics. The main difficulty lied in the precise prediction of the possibility of these environmental effects since no scientific evidence has been discovered yet to prove the risks of environmental harm caused by GM crops (2016, 122). Arcieri provided a more critical view on the subject of GM crops' potential risks and sees the technology as an unstable process with consequences that were difficult to predict (2016).

Nevertheless, many researchers still seem to have confidence in GM technology's overall stronger positive impact than possible adverse outcomes. Some proponents even advocate for commercializing GM products despite the risks, if the benefits can be proved to be higher than potential downsides and as long as they do not harm non-GM plants and human health (Azadi and Ho 2010,166). Zhang et al. conceded that the immediate benefits GM crops bring along were too tangible to dismiss, and a sudden halt on biotechnological development would neither be feasible nor should be encouraged. The authors advised continuing careful scientific evaluations of GM foods while paying attention to both its risks and advantages (Zhang et al. 2016, 122). Others like Fan et al. saw in biotechnology and its potential for increasing crop productivity a solution for the challenges global food production was facing but also emphasized the importance of considering all the involving factors that accompany the application of biotechnology (2012, 21).

2.6. International approaches to GM crops analysis

Apart from the literature on the general subject of biotechnology and GMOs, there is also research available on specific country cases, especially on the topic of GM crops. These scholarly works are of great importance for this thesis since its analytical framework builds upon these significant contributions from peer researchers. Interesting observations in reviewing these works of literature can be made, such as patterns among some countries that become visible after accumulating a number of similar cases. Reoccurring topics within these country cases include trade, policies, and GMO regulations in the respective country. Generally, a large body of literature with the focus on GM biotechnology's contribution in developing countries is represented throughout its development, since one of the main purposes of GM crops development is fighting famine and malnutrition (Azadi and Ho 2010; Ruane and Sonnino 2011; Adenle 2011; Trivedi et al. 2016; Huesing et al. 2016).

North and South America were among the first regions to have successfully adopted GM crops broadly. Therefore, studies on the country cases of these geographical areas dominate this field since they have the longest history and experience in GM biotechnology and its products. The literature on North American countries generally represents a more welcoming view towards GM biotechnology and its use in agriculture, which can also be observed in the research that focuses on country cases, such as the US and Canada (Smyth 2014; Adenle 2011; Coupe and Capel 2015; Trivedi et al. 2016). The first commercial GM crop production for food was initiated in 1994 in the US in the form of transgenic tomatoes. Nowadays, both the US and Canada have over 20 years of experience with GM crop production (Adenle 2011, 86; Smyth 2014, 195). Furthermore, authors who focus their research on these country cases also tend to have a skeptical opinion towards the comparatively strict approaches and regulations applied by the EU for GM crops (Zilberman et al. 2013; Wong and Chan 2016; Twardowski and Małyska 2015; Smyth 2017).

Smyth reviewed in 2014 Canada's GM crop production of the past 20 years from a social science perspective. Canada is considered one of the early and leading adopters in this regard. Due to its science-based regulatory framework, it is more inclined to develop biotechnological alternatives for agriculture in contrast to the EU, where politics dominates decisions regarding biotechnology's adoption. Trivedi et al. saw Canada as one of the top five countries in GM crop production with its adoption of GM canola, corn, and soybeans (2016, 709). Through enhanced crop production and reduced chemical costs, they reasoned higher profits for farmers due to rising adoption rates for different GM varieties. Both economic and environmental benefits result from the adoption of this technology (Smyth 2014, 201).

Coupe and Capel analyzed in their research the trends since the introduction of major GM crops in another one of the early adopters, the US (2015). Currently, GM varieties of crops seem to have largely substituted conventional crops. Predominantly GM soybean, corn, and cotton are being produced, used, and exported (ibid., 2030). GM biotechnology's most common uses are for the development of either crop resistance towards herbicides or production of plants with insecticidal compounds in them or, for some cases, even both. One of the US's main goals through GM crop adoption is to reduce the use of pesticides (Scandizzo and Savastano 2010, 143).

Researchers and supporters of North American approaches towards GM crop adoption tend to show skepticism towards the EU's measures on the same subject. Smyth et al. saw in several of the EU's biotechnology measures as "political decisions" without scientific evidence behind them, especially when determining thresholds for certain regulations (2014, 201). Twardowski and Małyska regarded the EU's reluctance and unfriendly legislation towards agricultural biotechnology as unproductive, accompanied by economic losses on both exporters and importers. According to the authors, most of the imported grains in the EU were already transgenic, and thus they called out for more "science-based approaches to policy in the EU" (2015, 2). In recent years similar skepticism can also be discovered among some European researchers. Bodiguel regarded the EU's science-based approach towards biotechnology adoption as far from successful. He observed a double procedure during the adoption, which started with a scientific approach, however usually followed and ended by a political choice (2016, 268).

Contrary to the literature on North American country cases, works on South American countries have taken a turn in recent years, moving away from considering solely the economic benefits of GM crops and turning towards socio-economic impact. While South America generally seemed to have a positive opinion on GM biotechnology's influence on their economy, several scholars did not share this enthusiasm for other areas, especially when considering socio-economic or ecological consequences (Leguizamón 2014; Lapegna 2014; Rótolo et al. 2015). Research on GM biotechnology's socio-economic impacts is nowadays more broadly represented and tends to treat this subject beyond the advantages it can offer, including the before mentioned controversies.

Rótolo et al. offered a comparative analysis of the different alternatives of maize production, including traditional, intensive and GM production. Their research concluded that GMO based crop production cannot always guarantee the expected improved performance in terms of productivity, sustainability and environmental cost (2015, 48). Leguizamón concentrated in her research on GM soy adoption and expansion in Argentina. She acknowledged the economic growth that GM soy boom has brought Argentina in a time of desperate need, however, questions its impact on many other factors, especially on socio-ecological sustainability (2014). Lapegna's paper shared similar topics as Leguizamón's and belonged to one of the rising works of research that focused on socio-environmental effects of GM crops and used an ethnographic approach to explain how people resist but also adapt to GM crops adoption (2014, 220).

2.7. East Asian country case studies

2.7.1. Studies on GM crops in China

Compared to country cases of the before mentioned geographical areas, the literature on GM crops in Asian country cases are rather sparsely represented, even more so on East Asian countries. Zhang and Zhou devoted their paper to China's reasons for using GM crops in the first place and also analyzed the socio-economic effects of using GM products in China (2003). Similar to the US, one of the reasons for applying GM crops, next to increasing yields, was to reduce the use of pesticides and mitigate the adverse consequences of its application on soil and water. The authors concluded from their survey that despite the economic benefits of GM foods, they still might not turn out to be favorable products in China if the government cannot provide safety reassurance of its consumption (ibid. 2003, 10).

Yan et al. focused specifically on the commodity of GM soybeans in their research on China's GM crop adoption (2016). They critically assessed China's role as the biggest global GM soybean importer and showed the different views on the country's changing soybean trade, the effects on domestic food security as well as the impacts on the exporting countries in South and North America. According to the authors, the massive soybean imports were being viewed by critics as a "lose-lose business," especially considering China's dependence on foreign resources and the ecological and health consequences caused by GM soybean production in Argentina and Brazil. China's necessity of increasing imports on GM soybeans caused a reassessment of the situation on food production, considering food sovereignty as an alternative (Yan et al. 2016, 391). Nevertheless, the more prevailing narrative in China remained in favor of GM soybean import, arguing the commodity's advantages in the face of the country's high population and limited land resources (ibid., 374).

Similar arguments can be discovered from fellow advocates in favor of GM crops in China. Huang and Gao concentrated in their research on the advantages of GM crop import, focusing on the commodity of GM soybeans (2014). The authors applied a rather pragmatic approach concerning soybean imports, arguing that from an "economic logical" perspective, it made perfect sense for China to acquire GM soybeans from abroad. Soybean production belongs to one of the most land-intensive crops with both low productivity and low-value generation. Therefore, Huang and Gao considered it an economic advantage for Chinese farmers to shift away from high-intensive crop farming of soybeans and substitute the required amount with imported goods. This way, the country can spare its own limited farmland. GM soy imported from the US requires less labor and production cost due to the use of glyphosate-based herbicides and the complementary glyphosate-resistant crop (ibid.). Chen et al. provided in their research an estimation of China's demand for GM soybeans and soybean oil and concluded that China will strive to remain the largest market for soybeans (2012).

Fan et al. analyzed in their paper ways to improve crop productivity and resource use efficiency with the ultimate goal of ensuring food security while maintaining environmental quality in China. In order to achieve these objectives, the authors emphasized in their research the advantage of increased productivity that GM biotechnology and GM crops can offer (2012). To show these aspects, the authors provided a summary of the historical trend of crop production in China, followed by an examination of the main challenges that stand in the way of the advancement of agricultural biotechnology. The authors regarded the development of agricultural technologies as a necessary step to improve crop and soil management and feed a growing population with limited arable land.

Considering that public concern about food safety is growing in China, Kou et al. focused in their article, next to the general administration of agricultural GMOs in China, specifically on the subject of safety regulations (2015). The authors described the laws and regulations that GM products need to undergo to enter the market. These included production and processing permission, as well as correct labeling. In the face of GM technology's potential, the authors concluded with the suggestion for China to keep promoting commercialization of GMOs, however under careful supervision, allowing for industry needs and public acceptance (ibid., 2163).

Even though there are studies available on GM crop adoptions in several countries, comparative assessments appear to be underrepresented, especially for countries in East Asia. When it comes to China, comparative studies combined with other country cases are not widely represented. Comparative assessments tend more likely to be found paired up with country cases of similar size and significance of GM biotechnology's role. Reoccurring country cases paired up with China for comparative studies can be found primarily on the US and India (Newell 2008; Wong and Chan 2016; Bhardwaj 2013). However, these studies tend to have a narrow field focus, such as comparing the countries' regulations on GMOs, and do not provide a holistic overview of the subject of GM crop adoption.

For example, Newell compared in his article the way, how China and India committed to international agreements on trade and biosafety of GMOs (2008). The two countries were chosen due to their significant role in the global debate on biotechnology. The author provided with his research a first systematic comparison of policy implementation between the two Asian countries cases and discovered that both countries attempted to domesticate global obligations in terms of trade of GM products and biosafety politics (Newell 2008, 135). Another article that provided a comparative assessment is composed by Wong and Chan. The authors analyzed GM foods in China and the US in their article with the focus on their regulatory frameworks (2016). First, they provided a general view of GM food and their risks and safety, followed by a comparative assessment of GM food adoption’s regulatory aspects in both China and the US. The authors were convinced that a revision of the current regulatory framework was overdue for both countries. Among the relevant regulatory aspects, Wong and Chan considered especially updates regarding strategies and policies in labeling and intellectual property soon to be necessary (ibid. 138).

Another article from Bhardwaj involves a comparative analysis of GM crops adoption in India, China, and Brazil (2013). The author analyzed GM crops' impacts on three different countries that differ widely from each other, not only in their land sizes and resources but also in their political regimes. This comparative research uncovered different problems and successes in each country. According to the author, China's success was mainly due to the state's dominant role, despite the country's environmental problems. Brazil, on the other hand, reflected the complete opposite situation with its inadequate government firmness. India seemed to similarly lack a firm regulation on several aspects of GM crop adoption while the farmers were left to additionally deal with ecological problems on their own (Bhardwaj 2013, 31).

2.7.2. Studies on GM crops in Japan

The amount of available literature on Japan compared with China is more limited. One of the reasons is the country's general skeptical view on GMOs, which confines the use and production of GM crops also (Umeda 2014). Therefore, research treating GM biotechnology and GM crops in Japan tends to focus on safety regulations and public perception, considering both topics' importance in this country. For example, Hino concentrated in his research on safety assessment and public concern for GM food products during the first years after their commercialization and introduction to Japan (2002). In his research, the author explained GM technology's importance and the worldwide need of GM crops to feed an increasing population whilst considering the general public's anxiety towards new technologies. Within the topic of safety assessments of GMOs in Japan, the issue of labeling arose as one of the major subjects. The author concluded that understanding and acceptance from consumers were crucial for the successful utilization of GM crops. He called out to provide consumers with the present state and scientific facts of GM food instead of unilateral criticism by mass media (Hino 2002, 128).

Nevertheless, it remains a relevant country case study for the subject of GM biotechnology and its food products, especially for one that increasingly struggles with self-sufficiency and is heavily dependent on trade to cover the population's demand (Kou et al. 2014, 2157). According to James, Japan imported a large amount of GM products since its own resources were particularly limited. As for many similar cases, alternative agricultural resources are of great importance for a country with not much arable land to begin with (2015, 11). In 2014, Japan turned out as the largest corn import country and third-largest soybean import country. Since most of the produced corn and soybean are genetically engineered, Japan also belongs to one of the countries that imports most GM crops (Kou et al. 2014, 2157).

Sato concentrated in his research on Japan's agricultural biotechnology, in which GM crops play a significant role (2016). The author covered in his research production, trade, policy, and marketing of plant biotechnology. The US’s role in Japan's trade on food and feed produced using biotechnology is a reoccurring topic when it comes to this East Asian country, considering the US is the historically dominant supplier for Japan. Regulatory approval by the government is considered by the author as one of the key subjects when it comes to trade with GM crops. Regulatory efficiency is especially crucial for their trade partners since harvested GM crops that are not approved by the government can lead to trade disruptions on both sides (Sato 2016, 2).

Masunaga dealt in her article with Japan's food crop trade and the country's attitude toward GM wheat imported from the US (2013). According to the author, Japan is well known for its strict safety assessments for food imports and its consumers for their food safety concerns. Both characteristics were reflected in the changes of Japanese wheat trade. Masunaga treated the Japanese government's conflicting attitude towards GM biotechnology in her article by showing, on the one hand, the health concerns of Japanese consumers, both in general for food safety, as well as directed explicitly towards GM food. On the other hand, she also revealed how Japan nevertheless remained one of the world's largest per capita importers of GM food and feed (ibid.).

Umeda analyzed, in her report, specifically GMOs in Japan and the restrictions that accompany them. Even though Japan is one of the largest GM crop importers, the public shares a skeptical view concerning genetically engineered food (2014). This is also the reason why Japan does not commercially plant GM food crops. Some Japanese prefectures place restrictions within their jurisdictions. Generally, the imported commodities are under strict labeling regulations that require labeling of foods if they have GM crop components. Japan's use and regulation of GM crops are primarily dominated by the degree of restrictions. Based on her research, the author concluded that GMOs’ intended use played a vital role in the level of required restrictions, which again influenced GM crop adoption (Umeda 2014).

In terms of agricultural commodities in Japan, several pieces of research focus on trade since many crops are being imported. One of the most traded agricultural commodities is soybean. Yamaura and Xia, for example, focused their article on the market power of exporting and importing countries and coexistence of non-GM and GM products by examining the specific agricultural commodity soybean. The authors discovered that the world agricultural commodity trade flow underwent crucial changes during the last decade. The US, Brazil, and China belong to those countries that produce major amounts of agricultural commodities and have especially expanded their GM crop production. Nevertheless, Yamaura and Xia discovered that in the case of soybean trade between Japan and the US, both countries almost shared the same market power (2016, 40).

Huffstutter's article concentrated on the trade blocks in 2016 by Japan and South Korea on wheat from the US when unapproved GM crops seeds were discovered in the area where the imported wheat was growing (2016). Japan proved to be careful as ever, halting all distributions until testing was finished. A similar incident occurred earlier in 2013 when a strain of GMO wheat was found growing amongst non-GM crops. South Korea's reactions in these cases seemed to be even more strict than Japan by suspending clearance of US wheat for food use altogether. Since 2014 Japan and fellow wheat importers started to test wheat imported from the US on a regular basis for biotech traits. The author predicted that both Japan and South Korea will continue to be extra careful until they had tested their import products (ibid.).

Yamaguchi and Suda dealt with GMO controversies in Japan in their article (2010). In their research, the authors showed the different perceptions of various biotechnology actors and their influence on the technology’s development and products. The authors structured the development of biotechnology and GMO’s perception in different time phases. While the industrial justification initially played a primary role in public acceptance, in the later phase the arguments shifted to civic concerns. This shift meant that at first, biotechnology was optimistically perceived as a tool to advance the Japanese economy. Governmental support was reflected in its endorsement of easing regulations on GMO research and development. However, around the mid-1990s, civic concerns on food safety started to gain the upper hand and curbed GM crops' development, production, and trade. These furthermore led to a phase dominated by market concerns of the industries, which began to react to the actions of civil society (ibid., 391).

There are currently no research works comparatively assessing the influential factors involving GM crop adoption in China and Japan. Therefore, this thesis represents a first attempt to provide an initial step towards contributing to this gap. The abundance of literature from peers on the general subject of GM crops and biotechnology is the reason for this thesis relying on already existing scholarly works of other country cases to aid its analytical framework. Based on the conducted literature review, it can be concluded that literature on China shows much more abundance than on Japan in terms of the subject of GM crop adoption.

2.8. The core literature for the composite AF

2.8.1. Background of the literature choices

GM crop adoption has been approached intensively within the past two decades, especially since it achieved its peak around the turn of the century. Many researchers have analyzed it in-depth in recent years, focusing on a vast range of different aspects. In the research field that focuses less on the S&T behind it but more on the economic benefits and socio-environmental impacts, academics demonstrated these based on various country cases. Since this research thesis involves a comparative analysis of two East Asian countries at its core, I considered it useful to lean on the literature already provided by peers on different other country cases and attempted to assemble the most crucial factors they dealt with in their studies for my research. By compiling and merging contributions of existing literature, I have tried to create a framework with the highest relevancy as possible for my country cases. Even though each country is unique in the way it deals with GMOs, they do share similar measures and procedures, especially in the early adoption phase. Relevant indicators and factors that are influential in GMO adoption in different country cases tend to overlap, reflecting their general importance. I consider these overlaps to indicate that these particular factors should be paid more attention to since they seem to be relevant for the GM crop adoption in several different geographical areas.

Argentina belongs to one of the first countries, which managed to adopt GM crops extensively, by initially focusing on GM soy only when nurturing GM crop expansion. It is the second-largest producer of GM crops and accounts for 21% of the global GM crop area. Its GM soy model has been repeatedly cited as an example for success (Choumert and Phélinas 2015; Oliveira and Hecht 2016; Aldemita and Hautea 2018), although in recent years, the literature on its controversial consequences is making increasing appearances (Goldfarb and Zoomers 2013, 74). Nevertheless, when considering the economic benefits, this biotechnology has indeed provided Argentina with an impressive profit. Burachik analyzed in his research the conditions that made it possible for Argentina to adopt and develop GM crops successfully. The author crystalized the crucial factors for both the adoption of GM biotechnology as well as specific GM crops cases, such as GM soy and GM maize, and explained the complex combination of circumstances that were necessary in Argentina's case for a smooth transition to the new technology (2010).

Against the obvious choices of selecting another one of the well-known bigger GM producing countries, such as the US or Canada, I have decided to use Mabaya et al.'s GM crop analysis of Africa as the second pillar study for my theoretical foundation. Comparative studies are generally not well spread in the field of GM crops. Works of research on the giant GMO-producers tend to be focused on very specific aspects instead of offering a holistic overview of the country's GM crop situation and how it came to be. This focus can mainly be observed in studies on the bigger GM crops producing countries in South America and the US. Studies on Brazil and Argentina are often either primarily focused on the economic profits GM crops brought along, hailing the technology as a success (Oliveira 2016; Goldfarb and Zoomers 2013; Turzi 2012) or concentrated more on the social and ecological consequences that accompanied the adoption of this biotechnology (Garett and Rausch 2016, Lapegna 2014). Mabaya et al.'s analysis, on the other hand, provides not only a framework that has been used on multiple African countries but also introduced many different influential factors that are relevant for the adoption of GM biotechnology. Furthermore, each of these factors is accompanied by several determinants, offering a detailed view over the specific influences for the adoption.

Vigani and Olper's study (2013) is chosen as the final pillar in order to round up the framework and gain an overall view as well as details concerning the regulation of GM biotechnology adoption. The regulatory sector is a crucial area when it comes to GM crop adoption and determines whether any product of this biotechnology will be able to gain an initial foothold at all and have a successful future development within the respective country. A suitable regulatory framework offers a productive environment for GM biotechnology to unfold its potential (Burachik 2010, 589). Vigani and Olper developed in their research a list of GMO standards that covers six different regulatory dimensions that are relevant for GM crop adoption (2013).

2.8.2. Burachik's examination of Argentina's experience with GM crops

Burachik analyzed in his research the conditions that led to Argentina's GM crop adoption and development (2010). The research was conducted with the interest that the conditions treated in his case study might offer insight into other present cases and contribute to their development. According to the author, the smooth high-level adoption that occurred in Argentina was only possible due to the alignment of several different factors during the early stage. Burachik attributed four main causes to Argentina's success, namely political willingness, diverse recruitment, farmers' support, and an effective regulatory framework. The positive economic and ecological impact can act as crucial incentives for the endorsement of important stakeholders (2010, 588).

Burachik first examined the country's political situation during the early adoption phase and stated that the authorities' willingness to study and implement any new technology is crucial for its launch (2010, 589). The smoothness of technological transition is one of the indicators in evaluating the success of GM technology adoption. The political situation has a great influence on it since governmental support of a new agricultural strategy can make a crucial difference in its trajectory (Leguizamón 2014, 150). The promotion of GM biotechnology by key political figures has proven to be an influential factor, not only in Argentina but also in other countries (Mabaya et al. 2015, 582).

Following a supportive political situation, the next crucial factor is the availability of necessary human resources. Argentina has solved this issue with a unique measure by assembling a staff with different backgrounds. Professionals and scientists from both the academic and the private sectors, were incorporated into the regulatory body. The recruitment was characterized with staff from outside of the government, thus lending the country its edge by setting science as the foundation for their regulatory framework from the very beginning (Burachik 2010, 589). The author attributed the regulation's "rational," "science-based," and "flexible" features to the diverse staff, that were brought in for an early creation of the regulatory framework for crops. In this regard, Argentina set itself apart from many other countries, that primarily employ staff with a bureaucratic background. Only with a suitable regulatory framework at the very beginning of the adoption has the smooth and fast expansion of GM biotechnology been possible. The science-based guidelines, on which the regulations were built on, offered the developers an environment to enfold their potential (ibid., 591).

“The ability to solve prevalent farmers’ needs” and gaining farmer’s support are crucial, especially once the regulatory framework is in place. Economic and ecological benefits from GM crops can act as incentives for farmers’ approval. Both benefits can be achieved by GM crops' new traits created through a favorable combination of crops and selected genes. In order to examine positive economic and environmental impacts of GM crops, Burachik chose those GM crops that are widely planted in Argentina, namely GM soybean and GM maize, and explained the benefits their modified traits were able to generate. The beforementioned two benefits are generally closely intertwined with each other since increased efficiency reduces both production cost and environmental strains (ibid., 588).

In Argentina’s case, both GM soybean and GM maize caused improvements in agronomic practices, inducing the before mentioned benefits. GM soybean allows farmers to switch from using several more expensive and dangerous herbicides to simply one single environmental-friendlier alternative. GM maize shows similar advantages when considering the reductions in the use of both toxic insecticides as well as herbicides. This enhanced food crop allowed farmers to switch from multiple expensive and more toxic chemicals to a single chemical with lower toxicity, saving not only money but also contributing to agricultural sustainability and their own health. GM maize can increase farmers' competitiveness with the improved traits by growing healthier products and enable higher yields (ibid.). Therefore, efficiency in agricultural production does not only contribute to sustainable agriculture but can also be translated into economic benefits (Lapegna 2014, 209). Apart from the possible reductions of insecticides and pesticides, GM crops also account for creating jobs once the respective GM crop is released (Burachik 2010, 591).

2.8.3. Mabaya et al.’s GM crop analysis on Africa

Mabaya et al. dealt in one of their pieces of research with African nations and their attitudes and adoptions of GM crops. The authors identified the main key factors that were considered to influence GM crop adoption across the continent. They argued that especially GMO policies are being guided rather by political than scientific considerations. Media and special interest groups can also have critical influence, especially when they advocate for the GMOs opposition (Mabaya et al. 2015, 557).

First, the authors evaluated Africa's current GM crop condition by viewing the international instruments that have been signed or ratified by several African countries, notably the Convention on Biological Diversity and the Cartagena Protocol on Biosafety. Both provide an applicable international framework regarding GMOs' adverse consequences on human health and the environment. Generally, the authors agreed on how heterogeneous African countries' GMO approaches and management were, especially concerning policy, legislation, and administrative mechanisms (Mabaya et al. 2015, 579). The research lists in total eight main key factors that influence GMO adoption, involving the following: "ministerial control of biosafety, peer country influence, stage of seed sector development, advocacy by key political figures, the media, activism, food security and technical capacity" (ibid. 577).

Similar to Burachik (2010) and Leguizamón (2015), the authors of this research also considered the government's stance on GMO as crucial concerning success in its adoption as well as further advancement in the field of biotechnology. One of the defining aspects of this factor is the government's choice of commissioning the specific department to oversee biosafety. Usually, either the ministry of environment or ministry of agriculture is put in charge with it - the former being traditionally focused on protecting the environment, while the latter's tasks generally involve food security and economic benefits for the country. Therefore, a ministry of environment tends to view many biotechnologies as an endangering factor to biodiversity and environmental preservation. On the other side, the ministry of agriculture rather supports GM technology as a productivity-enhancing alternative. The authors recommend looking at the stages of biotechnology policies in the respective countries for demonstrative purposes. There are also exceptions to this rule, but overall the authors agreed that the placement of biosafety oversight in the respective department could show a government's general stance on GM biotechnology (ibid., 578).

In the specific case of Africa, Mabaya et al. coined its countries' approach towards GM technology as the "wait and see approach," with less individual initiative but more cautiously observing its neighbors and effects on other countries first. This phenomenon can be noticed in many regions, usually with a leading country breaking the ice first for its neighbors. Once the leading country's adoption turned out to be a success, the neighboring countries tend to adopt

GM-technology policies in quick succession. Therefore, the authors considered peer country influence as one of the factors that can lead a nation towards GM biotechnology adoption (2015, 582).

The stage of seed sector development is another indicator, which can reflect a nation’s maturity for adopting GM technology. In order to introduce this biotechnology, the respective nation needs to have an advanced seed sector. Mabaya et al.’s research on this factor shows that the more advanced a country’s seed sector is developed, the higher are the chances for them to have functioning biotechnology policies. Countries with less-developed seed sectors tend to have GM policies only in draft forms. Furthermore, if a country has the availability of advanced seed varieties, it would also provide an incentive to pursue more advanced technology in agriculture (ibid., 583).

Key political figures can have pivotal roles in the adoption and advancement of new biotechnology. Not only a country's president but also ministers in relevant fields can strongly influence biotechnology's trajectory. According to Mabaya et al., especially ministers of health, environment, and agriculture can significantly affect public policies, which can be confirmed by several country cases. In Africa, Zambia showed in the past the most antagonistic opinions towards GM food. However, even Zambia's stance had been inconsistent and changed with every new president. On the other hand, Kenya is an example of how several senior political figures can weigh in on GM policy. In the past, its minister of agriculture, as well as minister of public health, have both advocated GM biotechnology adoption (ibid., 585). However, internal political disagreements can prolong processes in this area.

Another influential factor is the media, which plays as essential role, especially during the initial stages of GMO introduction and policies. The media is usually dominated by anti-GMO activists who are not restrained by the same rules as scientists. In many countries, there seems to be a lack of balance between GMO-supporters and -opposers since there tends to be a shortage of scientific reporters in most media outlets. Scientists are bound to provide verified evidence when publishing new findings and often not trained to share knowledge beyond their own. Next to scientists' apathy, popular media outlets seem to be the perfect incubator for sharing unverified dangers of GMOs. Mabaya et al. explained this behavior by pointing out that editors tend to publish materials that sell well and increase their audience. Since sensationalism of unverified dangers of GMOs tends to induce that effect, it turned out to be the ideal place for many activists to flourish (2015, 586).

The sixth factor the authors evaluated is the role of activism itself, which is also part of the Cartagena Protocol. The Cartagena Protocol recommends its signers to provide a forum where transparency can be offered to the public through input and feedback from both sides (SCBD 2000, 18). However, this tends to turn into a place predominantly occupied by anti-GM lobby groups. In Africa, NGOs represent most of the anti-GMO activists. Many GMO opponents also belong to civic organizations or religious groups who tend to show skepticism on new technology in general, specifically when its application might influence human health and livelihoods (Mabaya et al. 2015, 586).

A country's attitude can change under different circumstances. During times of food security crises, GMOs have the highest appeal and can be supported by politicians and farmers who share the same goal overcoming these hazards. The direr national food situation becomes, the more likely stakeholders are willing to consider more options in pursuit of practical and fast solutions. In cases of food security crisis, GM biotechnology is regularly included in their repertoire (ibid., 587). Therefore, causes for hazards, such as famine, ironically improves attitudes towards GM crops. Pest and disease appearances belong amongst them as well. These have the tendency of sudden outbreaks, leaving a nation only limited time for search of adequate solutions. In the face of dire conditions and limited time frame, people are willing to widen the scope of alternative choices. Droughts are one of the most hazardous causes for food security crisis, and in the face of their intensities, demand for drought-resistant crops rises (James 2015, 10). While food security crises occur with intensity, nutrition security has become a constant and prevalent issue on a more sporadic basis. GM crops can also be applied in terms of fighting malnutrition by increasing their nutritional value.

A country's willingness for GMO adoption alone cannot lead to an immediate application if the technical capacity in the respective nation has not been reached yet. A mature system capable of commercializing GM crops needs to cover its development, testing, and education. Next to expensive facilities with the necessary scientific tools, qualified staff must also execute tests for approval. All these requirements demand financial resources. While during a GM introduction’s initial stages policy and legislative frameworks are matters of priority, a compatible institutional arrangement is just as important, especially when the time comes for testing and releasing GM products. Risk assessments are also considered by Mabaya et al. as a mandatory process in order to monitor standards even after the approval and should be conducted on a regular basis. Since they are science-based, they too require a certain technical capacity for their execution. High technical capacity indicates a country's scientific maturity to adopt more biotechnology policies. The authors have found out that countries with higher technical capacities tend to have more available GM policies than those with lower technical capacities and show more confidence in managing new biotechnology. Many countries establish a national biosafety committee (NBC) as a national authority responsible for biosafety (Mabaya et al. 2015, 588).

2.8.4. Vigani and Olper's composite index of GMO standards

GMO regulation, despite influencing GM crop adoption usually in a restricting way throughout the process, contains essential guidelines for successful introduction. GMO standards vary from every country and reflect the preferences of different interest groups, such as consumers, farmers or industries (Vigani and Olper 2013, 32). Nevertheless, most countries share a similar set of applicable standards when new biotechnology for food is being introduced. Vigani and Olper provided a composite index on GMO regulation in order to examine its determinants in a wide range of countries. For the same purpose, their index is incorporated into the analytical framework of this thesis in order to cover a comparative analysis of the GMO standards (ibid.).

The approval process marks the front line for any country that considers introducing GMOs in its domestic market. GM products cannot enter a country without approval. However, the approval requirements within the process are highly heterogeneous among the nations. Nevertheless, Vigani and Olper detected two main approaches: the EU-based "precautionary principle" and the US-based "substantial equivalence." The first requires all products that came in contact with GM biotechnology to follow the foreseen regulatory measures, whether they contain traits from GM crops or are derived from them. This approach is notoriously applied by most EU members (2013, 33). Its requirement includes, next to the traditional risk assessment, also "research efforts in laboratories and fields" and "long-term monitoring of potential effects of GM crops on humans and environment" (Nishizawa and Renn 2006, 44). The latter offers exemptions for equivalent products from any additional approval requirements and adapts approval measures case-by-case (Vigani and Olper 2013, 33). These two approaches are polar opposites and can be considered as benchmarks for other approval approaches that lie in the middle between these two extremes.

The application of biosafety assessment or, more commonly known as risk assessment, is being increasingly applied across the world. This regulatory dimension is closely linked with the beforementioned approval process, which can generally only proceed with a positive outcome of risk assessment. Generally, it analyzes the capability of the new GMO to trigger harmful effects on humans, animals, and the environment. Those countries that are home to fragile native plants would be required to conduct tests that monitor potential gene flow from GM crops to their wild relatives (ibid.).

The regulation of labeling has the purpose of informing about products that contain GM ingredients. Unfortunately, it can also act as a hazard warning and therefore exert influence on the demand for GM or non-GM products. Labeling regimes differ from each country and are influenced by production, development, and trade. Similar to the approval process, countries bearing resembling economic backgrounds tend to share similar models of labeling regimes, since labeling also requires additional financial expense. Labeling cost is primarily set by the threshold level and public capacity of enforcing it. A restrictive threshold would require higher cost for not only its execution by the public authority but also the cooperation of industries to abide those rules (Vigani and Olper 2013, 33).

Traceability is an instrument that often goes hand in hand with labeling and thus also shares some of its requirements. Its function involves the efficient withdrawal of GM products from the food and feed market. This efficiency is especially crucial when unexpected health consequences on consumers or negative effects on the environment are unleashed. The high cost for this regulation lies in the involvement of all actors in the food chain, including farmers, elevators, operators, and retailers. In order to successfully perform a complete withdrawal, food history needs to be managed in a retraceable manner, including recordings of use and location of a product, which Vigani and Olper refer to as “recorded identification” (2013, 34).

The regulation of coexistence has the goal to provide not only consumers but also farmers with several options of the food they can choose from, including GM, traditional and organic products. The main tool to achieve coexistence is crop segregation, which is again a costly matter. GM and non-GM crops cannot be cultivated in the same field; even short rotations are not possible. However, not only inefficiency in cultivation triggers higher costs, but also the necessary mechanisms. For example, pollen flow is an essential issue requiring high technical expertise in managing. Next to technical capacity, cooperation between the involving actors, particularly neighboring farmers, and regulations in case of breaching are also necessary to enable coexistence of different crop varieties (Arcieri 2016, 558). Considering the necessary measures, the affordability of coexistence depends on the level of technological development the respective country can offer. Establishing coexistence strategies prove to be challenging, especially for policymakers. With very different needs between organic and GM farmers, it is difficult to find a way to suit all actors (Vigani and Olper 2013, 34).

As for the membership of international agreements, the authors have chosen the Codex Alimentarius and the Cartagena Protocol on Biosafety. These two international agreements are the most advanced and widespread agreements available. Many countries that have adopted GMOs are members of at least one of them. Codex Alimentarius offers a collection of international standards and guidelines to protect consumer health and encourages fair trade. Therefore, food that meet those standards are safe for consumption and to be traded with. As comprehensive as the standards are, the Codex cannot substitute national legislation (FAO/WHO 2018a). The CPB is the second agreement Vigani and Olper's have chosen and considered a main international instrument in regards to biodiversity topics (2013, 34). The protocol's purpose is to offer an approach to protect biodiversity, sustainability, and fair sharing and utilization of genetic sources. It recognizes both the potential of modern biotechnology to advance human well-being, as well as possible adverse effects of its products. It encourages access and transfer of biotechnology while offering procedures for the safety of the very same technology simultaneously (SCBD 2000, 1).

3. Analytical Framework

3.1. Structure of the Composite Framework

The AF for this topic is the result of a compilation of the beforementioned three existing pieces of research. By merging and filtering the relevant factors and indicators of these works, I have attempted to create a composite framework specifically designed for my research. The AF has a two-level structure and is divided into two main sections. The first section contains influencing key factors before the adoption, which leans strongly on Mabaya et al.'s research (2015) supported and complemented by Burachik's work (2010). It focuses on influential factors during the time frame before the actual adoption takes place.

The first core literature and one of the main pillars for the theoretical part of this thesis is Mabaya et al.'s GM crop analysis on Africa (2015). Their research opens with a short overview of the current GM crop situation in Africa, followed by identifying crucial enablers and hindrances for GM crops on the continent. The factors that the authors accumulated for their research cover a wide range of different dimensions, from control on the political level to technical capacity. Since Mabaya et al.'s research span over the whole continent, including many heterogeneous approaches from different African countries, I regarded the analytical components of their work also applicable to my country cases, which showed similar ambivalent attitudes along with their approaches towards GM crop adoption.

Burachik evaluated in his research (2010) not only the economic benefits, that arrived along with GM crops, but also consequences on socio-environmental dynamics in Argentina, which is being widely being praised as a success model (Leguizamón 2014, 149; Choumert and Phélinas 2015, 134; ISAAA 2016, 19). Even though the focus of Burachik's work is not completely ident with this thesis, its structure and content provide an advantageous fundament for research in a similar field. Unlike the previously mentioned work by Mabaya et al., Burachik pays more attention to the multifaceted benefits as well as consequences that can both be caused by GM crop adoption.

The second section is devoted to the regulatory issues that play important roles both at the proposing stage as well as during the adoption. Relevant regulatory aspects are extracted from Vigani and Olper's index of GMO standards for production and commercialization regulations

(2013), which represents the third core literature. Unlike the previously mentioned two pieces of core literature, focusing on factors that are especially relevant before the adoption of GM biotechnology, I have chosen a third study dealing with influential regulatory factors that are crucial during the GM biotechnology adoption. Vigani and Olper composed a list of various regulatory topics that are crucial when dealing with GMOs and especially relevant during the adoption phase. The authors considered particularly regulatory factors, involving the institutional environment and the structure of the agricultural sector, to have a substantial influence on the development of GMO adoption (ibid., 32).

3.2. Composite AF for GM crop adoption

3.2.1. Influencing key factors before the adoption

3.2.1.1. Ministerial control of biosafety

A government's position on a new technology has an essential influence on its introduction into the country, therefore also on biotechnology and thus GM crops adoption (Mabaya et al. 2015, 580). The jurisdiction over biosafety represents the government's stance. It is the most influencing element at this key factor's core, which means that the department or ministry in control determines a major part of the fate of the development of biotechnology within a country (Gupta and Falkner 2006; Okeno et al. 2013; Schnurr and Gore 2014). The task of overseeing biosafety traditionally falls under either the ministry of agriculture or the ministry of environment (Mabaya et al. 2015, 580), although there are also examples for the ministry of science (Gupta and Falkner 2006). Each ministry has its own approach towards biotechnology and is represented by participants with different or even opposing motivations.

Considering that the main task of a ministry of environment involves the protection of the nation's natural habitat, its view towards GM biotechnology and its products tends to carry suspicion. A ministry of environment is inclined to approach this subject more cautiously and sees in GM crops more danger to their responsible territory than its potential for benefits. In contrast to the ministry of environment, the ministry of agriculture prioritizes a country's food security and economic growth. To achieve its goals, a more welcoming approach towards agri-biotech and GM crops can be witnessed and its members are much more willing to promote this technology. Therefore, a ministry of agriculture tends to focus on the advantage of enhanced productivity brought by the adoption of GM biotechnology (Mabaya et al. 2015, 581).

For the sake of completeness, it also should be mentioned that the oversight of biosafety does not necessarily have to be restricted to just one ministry but can also involve several departments. Some countries apply a dual approach, in which case both involved ministries are required to consent to any choices made concerning biotechnology. However, the more departments are involved, the higher the costs will grow along with the adoption of the technology and time consumption for regulations (ibid.). In the rare case of Zambia, six ministries are involved in all decisions concerning biotechnology, which enormously slows down any development of the technology (Okeno et al. 2013, 126).

Mabaya et al. recommended to determine a country's placement of jurisdiction over biosafety, the department's motivation, and the stage of biotechnology policy. A ministry in support of GM biotechnology and GM crop adoption would attempt to achieve the advancement of the respective technology by introducing favorable policies (2015, 581). These national policies ideally should encompass the promotion of biotechnology, including its products and their safe use, a balanced approach of risk assessments of the natural environment and human health, and the importance of stakeholder input. A country that has the promotion of all three beforementioned subjects covered has a mature system of biotechnology policies. The more these three basic policies are incorporated in a country, the more mature the overall stage of biotechnology will be (Burachik and Traynor 2002, 43). Countries with only draft policies on GM technology tend to house biosafety in a ministry that is more reluctant towards its advancement (Mabaya et al. 2015, 581).

3.2.1.2. Advocacy by key political figures

Similar to the responsible department, political figures can both affect and be affected by other factors that are relevant for GM crop adoption. On the one hand, they can affect the future of a country's GM crop adoption by drawing up and approving those biotechnology policies complying with their own objectives, which tend to reach beyond scientific means. On the other hand, they are also subject to influences, such as public opinion, that can again be influenced by the media, which is another factor that will be treated in the analytical framework (Mabaya et al. 2015, 585). Political support is considered by Burachik (2010) and Mabaya et al. (2015)

as one of the most influential factors before the adoption. Especially Burachik attributed the initial success of new technology adoption to the authorities' willingness to promote its study and development, like the former secretariat of agriculture did in Argentina (2010, 589). Leguizamón similarly devoted a good part of her research to the roles of key political figures in Argentina’s GM crop adoption. Each president in office can influence the focus before and during the adoption phase. With the change of presidencies, political views on GM biotechnology can alter along and move either towards improving or deteriorating terms (2014).

According to Mabaya et al., not only presidents in office can play a crucial role, but also other senior political figures with definite opinions on this subject, especially those from the departments that are prone to receive oversight of biosafety, such as ministers of agriculture and environment. Positive views on biotechnology and GM crops can smooth the approval process and aid their way towards commercialization (2015, 584). Evidence for this phenomenon can be found in Argentina’s case under Kirchner’s administration, during which the South American country experienced important advancements in GM biotechnology (Leguizamón 2014, 157).

However, if the opposing view is strong and expressed by dominant political figures, then the polar opposite will become a likely result, despite all scientific efforts and evidence of GM crops’ benefits. Therefore, a government’s stance on this subject is precarious and easily susceptible to political changes, depending much on the endorsement or discouragement of ministers. Internal unity or struggles in the government influences politicians’ stances and the state of GM policies, which reflects a country’s GM biotechnology acceptance and the level of consent among the key political figures. Long-term draft policies can be a sign of internal struggles between different interest groups and warring political opinions inside and outside the government. Especially elected politicians are susceptible to public influence, which can be changed by providing more information through public awareness promotion. However, it is much easier the other way around for the public to lobby against GM policies by initiating anti-GM campaigns (Mabaya et al. 2015, 585).

3.2.1.3. Peer country influence

Countries tend to look at their neighboring and peer countries for guidance when it comes to new adoptions. The evaluation of these countries’ choices can help to determine the regional competition and follow regional trends. Therefore, GM crop adoption by one country has the potential to trigger contagion effects on neighboring states. Generally, GM technology, at its early development, used to be considered by the majority as foreign and risky (Dibden et al. 2013, 60). With peer countries on the front, such as North and South American nations, many other countries have applied the safer option, which Mabaya et al. refer to as the “wait-and-see approach.” Once the adoption in one country has proven successful, others tend to be more willing to follow suit (2015, 582).

For the occurrence of peer country influence, a strong early adopter is necessary to lead the path, especially when it comes to unchartered technical territory within the region. Argentina, for instance, assumed this role in Latin America with its prominent pro-GM biotechnology stance. As the earliest adopter in its region, it remains one of the main promoters of GM crops in South America (Leguizamón 2014, 150). In West Africa, Burkina Faso was the first to commercialize GM crops, followed by its neighbors, whose farmers observed GM crops’ success, and some managed to pressure their government to provide similar access to the same technological advance. In the years following Burkina Faso's adoption success, Ghana, Nigeria, and Cameroon followed suit (Mabaya et al. 2015, 582).

Peer country influence is, however, not limited to neighboring countries only. International cross-continental influence is a common phenomenon in recent decades, considering GM biotechnology originating in the US and has now found recognition and adoption globally (Coupe and Capel 2015, 1013). Furthermore, peer country influence is not restricted to merely stimulating consideration for GM crop adoption, but can also have a spillover effect on other countries’ GM biotechnology regulations. One of the commonly affected regulatory dimensions is the labeling regime. Vigani and Olper discovered evidence on this subject, predominantly in labeling choices made in developing countries. The authors consider labeling standards to be more susceptible towards outside influences, especially if they involve trade relations that can affect their economies (2013, 34).

3.2.1.4. Technical capacity

The technical capacity factor involves several sectors that are necessary to be achieved at a certain stage during or even before the actual GM crop adoption phase. Therefore, technical capacity remains one of the primary challenges for any country, that is considering or heading towards the early stages of GM biotechnology or GM crop adoption, due to its many demands that reach beyond technical requirements. According to Mabaya et al., for a GM crop to be successfully introduced, a technical system for R&D, testing, and commercialization is needed. Often it also involves education about the new crop. In order to fulfill all these demands, advanced technical capacity is necessary, which involves not only technical facilities, "but also highly skilled personnel, scientific tools, and financial resources to test and approve each GMO event" (2015, 588).

Progress in agricultural S&T is the fundament for advancement in the agriculture sector. Agricultural innovation and advancement in key industry technologies, including genetic engineering or modern breeding technologies of various food and feed crops, are crucial for a country's enhancement of technical capacity to achieve long-term goals, such as sustainable crop production, efficient use of limited agricultural resources, water-saving methods and cropland improvement. Breakthroughs in biotechnology also induce the expansion towards neighboring sectors, such as the seed industry, which correlates with technical advancement. The application of modern seed industry stimulates the development of key industries in the biotechnology sector and vice versa since advanced technical capacity is also necessary for both the development as well as the application of modern seed varieties and their plants (Xu et al. 2017, 97).

For the production and commercialization of GM crops, a well-developed seed sector is essential (Mabaya et al. 2015, 583; Leguizamón 2014, 151). GM crop adoption and stage of seed sector development are positively correlated with each other. According to Mabaya et al., an advanced seed sector can be a key driving force for GM crop adoption. By applying advanced seed varieties, the need for productivity-enhancing technologies rises, including GM crop adoption. A seed sector does not only involve production but also covers the responsibilities for efficient distribution to smallholder farmers and keeping seeds at an affordable price for them. Some advanced seed sectors can also bear educational responsibilities towards farmers, such as training in efficient seed management (2015, 583). Therefore, a functioning seed supply system can make a crucial difference for farmers to adopt agricultural products derived from biotechnology, such as GM crops (Lusser et al. 2012, 38).

To reach both successful GM biotechnology and GM crop adoption, not only relevant policies for innovation in place are necessary, but also institutional arrangements to process applications of GM crops. Risk assessment can also be considered part of technical capacity as an important scientific tool to keep the authorities updated, both before and after the adoption. Similar important are capacities for post-approval monitoring and inspections. In some country cases, administrative arrangements for biosafety and food safety of GM crops exist in the collective form of a national biosafety committee (NBC) to oversee this issue (Okeno et al. 2013, 128). According to Mabaya et al., a well-developed NBC plays a crucial role in the adoption of new biotechnology and its products (2015, 588).

Similar to Okeno et al. (2013), Burachik also devoted a part of his research to the importance of competent human resources, which is another essential component of technical capacity. Specialists are not only for the field trials essential but also for the creation of an initial regulatory framework, which is vital for establishing an environment that effectively handles a newly adopted biotechnology. The author especially advocated for staff with diverse professional backgrounds, preferably even from the outside government, in order to apply a science-based and effective approach early during the GM crop adoption phase (2010, 589). Indicators for the criterion of human resources the numbers of people engaged with R&D, the existence of NBC, and the availability of other technical entities with similar and supporting functions. The scope of available staff in R&D and their professional background are both indicators determined by Burachik's (2010) and Mabaya et al.'s works of research (2015). Both studies emphasized the importance of sufficient professionals from diverse backgrounds in a productive S&T environment for biotechnology to flourish.

Human resources will be jointly analyzed with the financial resources that are invested in the R&D of the S&T sector, enabling research, tests, and approvals in biotechnology, among other technologies. The selected period ranges from the earliest to the latest year for which data are available for both countries. Data will be collected at two-year intervals. A comparison of each country's scientific plans is expected to offer insight into the previously set and recently achieved goals for each time range. China's Five-Year Plans for S&T, as well as Japan's Basic Plans for S&T, are both sources for information on planned and achieved human and financial resources for R&D, as witnessed by Gilmour et al.'s (2015) and Holroyd's (2014) works.

R&D personnel includes people who perform R&D, such as scientists and engineers, and those contributing to R&D projects, such as researchers, and also technicians and supporting staff. These data are mainly of interest for policymakers and scholars since they reflect the size, availability, and demographic patterns of human resources that contribute to the R&D sector (OECD 2015, 150). Even though R&D personnel encompasses not only individuals performing the actual scientific and technical work but also those who plan and manage the R&D project, not all of them have a share in the final totals of R&D personnel. In statistical measurements, only the R&D personnel who make direct contributions to R&D projects are included (ibid., 151). Recommended measurement units by the OECD for a country's R&D human resources are the headcount (HC) and the full-time equivalent (FTE) of R&D personnel (ibid., 165).

The FTE is considered as "the true measure of R&D personnel statistic," especially in terms of international comparisons, while the HCs are recommended for exploratory purposes of the characteristics of R&D personnel and provided usually in percentage terms. The FTE of R&D is defined by the OECD as "the ratio of working hours actually spent on R&D during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period by an individual or by a group" (ibid., 166). Generally, one single person can account for one FTE only in a single year, and thus not more than one FTE on R&D can be achieved by one person annually. The HC of R&D personnel equals the total number of persons performing R&D (ibid. 167).

The reason for both FTE and HC being recommended as indicators is to balance out over- and underestimations. Personnel's R&D efforts can be performed as a primary function by some individuals, like researchers in a lab, or as a secondary function, such as members who work in design or testing establishments. Another distinction can be made between R&D personnel on full-time basis, and part-time basis, such as performed by professors, students, and consultants. Therefore, including only individuals with primary function as R&D would lead to an underestimation of the efforts invested into R&D. On the other hand, including every individual who spends any time at all on R&D would lead to an overestimation (ibid., 165). This is also the reason why the FTE is considered the main indicator for R&D personnel since it calculates the working hour actually spent on R&D. The HCs and the FTEs together can offer complementary information on the subject of R&D personnel.

The R&D expenditure covers the amount of money a country spends on research and experimental development. The determination of R&D expenditure is essential in the interest of national and international policymakers and can be used to provide insight into the development of financial incentives for the stimulation of R&D activities. This information could also help to understand R&D's contribution to related fields, such as economic growth and social well-being (ibid., 110). To measure expenditure on R&D's performance in a country, the OECD recommends determining the gross domestic expenditure on R&D (GERD). The GERD is a key indicator and covers the total expenditures for R&D performed in a country during a certain period (ibid., 111). The R&D performance includes the research areas of "basic research, applied research, and experimental development" as well as the sectors of "business enterprise, government, higher education and private non-profit" (World Bank 2019a).

Both annual R&D expenditure in the form of GERD in current Purchasing Power Parity Dollars (PPP$), as well as the R&D expenditure as a percentage of GDP, will be accumulated in the empirical part and compared with each other in the analytical part in order to achieve a more effective comparative analysis (Montoya and Chalaud 2016). According to the OECD, the GDP ratios can be useful by normalizing large differences in countries' R&D totals, which in some cases reflects simply a substantial difference in the size of the respective country's economy (OECD 2015, 144). The comparative analysis of financial resources will lean more on the GDP percentage, since it is the main recommended indicator by the UIS for evaluating a country's commitment to domestic R&D (2019a).

3.2.1.5. Food security crises

Several researchers see great potential for agricultural biotechnology to contribute to food security, especially considering GM crops as a solution for food crises (Mabaya et al. 2015; Dibden et al. 2013; ISAAA 2016; Franke et al. 2011). According to the Integrated Food Security Phase Classification (IPC), there are different levels of severity of food insecurity. These are differentiated in five severity phases with "minimal/none" being the first, "stressed" as the second, "crisis" as the third, "emergency" as the fourth and "catastrophe/famine" as the fifth phase (IPC Global Partners 2019, 32).

There are several causes of food security crises, with growing environmental challenges being the most crucial in agricultural food production. In the face of these challenges, GM plants' main purpose and advantage lie in their achievement of developing tolerance and resistance against these stresses (Tsatsakis et al. 2017, 108). Environmental challenges, such as droughts, pests, and diseases, can turn into essential GM crop adoption incentives. Especially heat and droughts can have catastrophic consequences for a country's agriculture by interfering critically with its irrigation, thus causing heavy yield losses. In order to counter these environmental hazards, countries tend to be more willing to broaden the range of options and take GM biotechnology into consideration, especially when a solution in the form of a resistant GM crop is already available (Jones et al. 2017, 160).

Based on Mabaya et al.'s findings, food security crises can enhance people's tolerance towards GM biotechnology and its products - unlike during a time of surplus, when alternatives are not in immediate need. In times when demands are more apparent, it seems that the process of adoption can be accelerated in order to achieve a solution as fast as possible. In the face of a food security crisis, stakeholders gain a much more open attitude towards a broader range of alternative options in search of an instant fix (2015, 587). This provides a first or even second chance for GM biotechnology and its products, including countries that were reluctant to adopt GM crops in the first place. Even though not all food crises can be solved with biotechnology, in the several cases of pest or disease outbreaks of sterile plants, it remains one of the most effective and feasible options (ibid., 588; ISAAA 2016, 1). These outcomes can also be relevant for farmers and ease their agronomic practices, although not all benefits have to be equally applicable for each of them (Klümper and Quaim 2014, e111629).

At each of their early stages, food scarcity and famine's consequences lack immediate signs, unlike environmental hazards that leave their waste and victims visibly behind. Famine is especially relevant in several developing countries, and can either trigger new perspectives of farmers and policymakers in some countries or reflect the stubbornness of others despite facing the drastic need for food. In the case of Zambia in 2005, food aid in the form of GM crops was banned by the government even though the country was facing severe famine. However, pressure from an affected country's people can create a more receptive environment, by pushing its government to accept the needed aid and reevaluate the adoption of GM biotechnology (Mabaya et al. 2015, 588).

A repeatedly cited success model is Argentina, whose GM crop adoption is induced by the country's political and economic crisis in the 1990s, which left half of its population in poverty (Newell 2009; Burachik 2010; Leguizamón 2014). GM soy-based revenue became a major contributor to solving not only Argentina's food but also its national economic crisis. Once food security was restored, GM soy remained crucial support in the form of a source for foreign income from increasing soy export. The promotion of agricultural technology grew into a core element in Argentina's development strategy based on GM soy adoption's success (Leguizamón 2014, 156).

3.2.1.6. The role of media and activism

Mabaya et al. summarized the role of media and public influences on biotechnology policy with a chain of policy drivers, in the following order: 1) media, 2) public opinion, 3) politicians, and 4) policy. The chain starts with the factor media that responds rapidly to sensationalism and, in the case of GM biotechnology, is strongly driven by civic activism. These two aspects tend to share challenging views on the subject GMOs and can easily sway public perception through the media. Politicians again can be similarly affected and are generally more interested in representing public opinion than science. Policies without enough support from politicians are again not likely to be drawn up. Currently, GM biotechnology is still struggling to find support, which comes much more reluctantly than skepticism or opposition. The fact that social media's influence dominates public opinion is among the causes of this tendency (2015, 585).

Several pieces of research confirm the media's crucial influence in affecting consumer perception and food safety standards (Olper and Swinnen 2013; Vigani and Olper 2013; Zheng et al. 2017). The media is a tool that can be wielded by various stakeholders und distinguishes itself also in various types, such as television (TV), radio, print media and online media (Han et al. 2015, 1). Information provided by the mass media can induce various social groups to act either in a supporting or opposing manner towards policy-making (Olper and Swinnen 2013, 413).

According to Vigani and Olper, one of the essential drivers of GM policies, and thus the GM crop adoption, is the structure of domestic mass media, which encompasses several indicators that depend on the proportion between public and private media (2013, 37). The most relevant indicators for this research are the control of media, the function of media, and the main target groups (ibid.; Mabaya et al. 2015, 585). Public and private media are distinguished in their opposing objectives. While the private media is more commercially oriented, public media has its focus on forwarding national policies. Private media's objective is to expand media consumption, which can be achieved more easily by arousing consumers' interest via sensational news, since "negative items have more impact than positive ones" (McCluskey and Swinnen 2011, 626). In terms of the adoption of GM crops, food scares would be an example that led consumers to demand restrictive GMO standards. On the polar opposite is usually the public-controlled media with less variety of information that is controlled in a way that tends to promote national policies (2013, 37).

The beforementioned structure of media is also dependent on the level of economic development. Public-controlled media are often prevailing in developing countries, whereas developed countries tend to have a media market structure with high heterogeneity, often with many different private media companies competing with each other. The caused media competition can, on the one hand, induce higher demand for quantity of information, but on the other hand, lower the quality of information. The downside of high competition is that media companies tend to turn towards sensationalist news in order to target large consumer groups. Once convinced by the media, these consumer groups would support these views, which again can cause policy bias by politicians who attempt to gain the favor of large numbers of voters. According to Vigani and Olper, this is how information bias can translate into policy bias, thus leading to restrictiveness in GMO standards and complicating the process of GM crop adoption (2013, 42).

Another set of criteria in the role of media includes awareness and acceptance. Both can be achieved and advanced but also discouraged through media consumption. Since mass media generally aims for the largest groups, these tend to be better informed than others. In developing countries, especially those with agriculture-based economies, farmer groups tend to be large and dominant. Mass media promotes in these countries agricultural policies in favor of the farmers. On the other hand, in developed countries with small farmer groups, media tend to target consumers (Vigani and Olper 2013, 38). Since the consumers represent one of the substantial stakeholder groups, it becomes even more crucial to detect their perceptions of GM food to influence purchasing behaviors and support consumers with well-informed decisions.

Therefore, the views of specifically the two largest groups of consumers and farmers have been identified as indicators for the criteria of each country case’s awareness and acceptance of GM crops and GM biotechnology since both groups’ perceptions are susceptible to media (Komoto et al. 2016, e23). According to McCluskey and Swinnen, availability of access to media, leisure time, and range of choice in media can also influence consumers’ media consumption and their risk perception (2011, 625). This argument is also used by Vigani and Olper to explain the tendency of low risk perception of consumers in developing countries where options of the beforementioned three conditions are more limited than in developed countries (2013, 37).

Debates and activism are represented in several pieces of researches in the context of media due to their sensational view they can cause (Vigani and Olper 2013; Mabaya et al. 2015; Yan et al. 2016). The source of activism and debates should be identified in a first step. In some countries civil society groups are the key drivers (Mabaya et al. 2015, 586), while in others prominent individuals play an important role, such as journalists, activist citizens, or commentators (Yan et al. 2016, 383). While most NGOs and activists are dominated by anti-GM lobby groups, not all debates share the same view for the same cause. According to Yan et al., it is therefore crucial to recognize the source and reason for the prevalent debates and oppositions (2016). The source of information for many participants of debates and activism is the media, which again can influence their perceptions depending on their nature and objective.

3.2.2. Influencing regulatory components during the adoption

3.2.2.1. Approval process and risk assessment

When analyzing the approval process in different countries, the first step is to determine the main approach, whether it is the EU-based "precautionary principle" or the US-based "substantial equivalence." The application of the approval process can further be distinguished in the scope of its execution. For example, it is possible to have a mandatory approval process legislatively decided, but not enforced yet. Generally, the state of GM policies can provide insight in this regard (Vigani and Olper 2013, 33). According to Aldemita et al., approval for each GM crop event can be issued up to three times, respectively, for food, feed, and cultivation each, depending on the country's regulations (2015, 152). De Faria and Wieck analyzed asynchronous approval (AA), which is a common phenomenon within the approval process. It occurs when a new GM product is not simultaneously approved across countries and can potentially interrupt trade (2016, 85).

Some nations have the additional requirement of approval renewals within this regulatory dimension. In order to control GMOs, the renewal process certificates can be issues with a definite expiry date. This, however, also means that if an expired certificate that has not been renewed on time can cause the beforementioned AA situation and trade disruptions (ibid., 87). Therefore, heterogeneity within the approval process and discrepancies in the amount of time needed for the approval of new GM crops are both drivers of AA situations (Kalaitzandonakes et al. 2014, 147). When it comes to trade, the authors distinguish between three different types of threshold policies for importing countries, namely the "zero-tolerance policy," the "low percentage threshold policy," and the "case-by-case policy." There is a tendency that shipments towards countries with lower thresholds are more likely to face rejection than countries with more relaxed threshold policies (De Faria and Wieck 2016, 89, Gruère et al. 2011, 285).

As previously also pointed out by Mabaya et al., risk assessments usually involve repeated examinations to guarantee the continuous safety even after the approval (Mabaya et al. 2015, 588; Vigani and Olper 2013, 33). These are closely intertwined with the approval process since approval is dependent on the positive outcome of risk assessments and involve in general effects GM crops can have on agronomical practices and their possible environmental impacts (Burachik 2010, 589). Countries that do not have this regulation are either GM-free countries or omitted it in favor of not interrupting trade. However, the majority of GMO trading countries either follow mandatory risk assessment or at least have it in a proposal stage. Countries with delicate native plants have to be especially cautious and apply tests for potential gene flow from GM crops to their own flora (Vigani and Olper 2013, 33). The Cartagena Protocol offers a framework for risk assessment as a guideline for countries without any (Bouët et al. 2013, 15).

The EU recommended not only to include natural science into the procedures for risk assessment and risk management but also to expand the scope to social sciences, law, ethics, and civil society as well (Arcieri 2016, 558). Burachik, on the other hand, advocated for a rational, science-based regulatory framework, especially during the early adoption phase for higher efficiency, although without excluding societal interests completely either. Independent of the country's general approach, risk assessment remains one of the most expensive regulations due to its expensive field programs and time-consuming application. The extensiveness of the tests and the consistency of rules for the results are crucial for passing the risk assessment (2010, 589).

Influential elements in this regard that affect the commercial use of GM crops include variability, testing sensitivities, and the threshold for positive results in the labs for the risk assessment. Variability refers to the capabilities of those labs that conduct tests for imports but do not have consistent technical competencies. Even though all labs use polymerase chain reaction tests, there are still differences among them. For this method, import tolerance can range from 0.1 to 0.01 percent. High testing sensitivities have restricting consequences for the commercialization of respective commodities. A set threshold is a crucial reference point for the exporter to pass the approval process and to unify the range of acceptable positive results for testing facilities (Ma et al. 2017, 462).

3.2.2.2. Labeling and traceability

Labeling belongs to one of the costly regulatory measures that can require higher financial investments depending on the scope of its application. Developed countries show the tendency to adopt more elaborate GM labeling on a mandatory basis. Countries that show less agricultural dependency have a similar approach since customers from these countries often have higher demands concerning food information. On the polar opposite, nations that produce or export GM products tend to have a more pragmatic approach towards this regulation involving less elaborate, thus also less costly labeling measures (Vigani and Olper 2013, 34). Labeling in developing countries are partially subject to peer country influence and trade relationships; therefore, their labeling applications tend to be rather heterogeneous.

The financial aspect of labeling is determined by the threshold level and the capacity of relevant actors executing and complying with these policies. The chain of involved actors includes the public authority that carries the responsibility of enforcing labeling policies, and the affected industries that are required to fulfill the labeling rules. Therefore, the more restrictive a labeling threshold is, the higher the application costs will become. In terms of trade, the importing country sets the bar for labeling in the producing country that wishes to export its GM products. Depending on the receiving country's regulation, labeling measures for trade purposes can turn out to be more complex than for domestic consumption or processing within the country (ibid., 35). Apart from the financial aspect, another argument against labeling is that this regulation seems to imply reasons for concern about the consequences of consumption (Okeno et al. 2013, 127).

Vigani and Olper distinguished in their GMO standards between several different categories of labeling, including countries with voluntary or mandatory regimes. Not all mandatory labeling regimes are the same, and their restrictiveness depends on the set threshold, which is generally either above or below 1 percent (2013, 34). In this regulatory dimension, several authors considered "labeling type, labeling orientation, labeling threshold and coverage" to be important (Gruère and Rao 2007, 61; De Faria and Wieck 2016, 80). Within countries with labeling standards, researchers generally distinguish in this regulatory dimension between countries with a voluntary regime or mandatory regime. Mandatory labeling regimes are then again distinguished between having a threshold higher or lower than 1 percent (Vigani and Olper 2013; De Faria and Wieck 2016). However, even among countries with mandatory labeling regimes themselves, there are differences between the regulation of their labeling approaches. They are distinguished from each other by their regulation target, which can either focus on the presence of GM traits in the end product or on the very GM biotechnology itself as a production process (Gruère and Rao 2007, 52; Vigani and Olper 2013, 34).

Another one of the costlier regulatory instruments is traceability, which is often required from labeling as well in order to trace a product's original components for thorough research before applying an actual label (Gruère and Rao 2007, 61). It is especially important when a GMO product needs to be withdrawn from the market when discovering the possibility of endangering health and environment. Traceability is generally wielded by countries with sufficient financial capacity only, due to its complex execution and high cost. In order for it to function efficiently, all actors of the food chain must be involved. Farmers are required to abide by certified storage and harvesting. Operators and retailers have to preserve information on product identity and use lot numbers to initialize them. This information then again needs to be maintained for a certain time period, which varies across countries, and have to be accessible to applicants (Vigani and Olper 2013, 34).

A well-developed system for traceability or identity preservation (IP) system can both be standard tools for the means to this end, although traceability is attached with more complexity in its implementation and higher compliance costs. Countries with only limited financial resources tend to refrain from this elaborate procedure. By contrast, many developed countries are equipped with it, especially EU member states. Developing countries often do not sufficiently fulfill the requirements for this costly instrument and tend to have traceability only at a proposal stage (ibid.). With traceability being a crucial but also niche regulatory component, the extraction of its information can be challenging.

3.2.2.3. Coexistence

With growing GM crop adoption, the issue of coexistence between GM crops and non-GM crops arises in order to offer farmers and thus the consumers the ability to choose between conventional, organic, and GM crops. The advantage of maintaining different agricultural production systems is reflected in the consumer world with increased options when it comes to food (Demont and Devos 2008, 353). However, in order to achieve coexistence, specific administrative and technical measures are required due to the incompatibility between the production methods. Organic farming requires high specifications that are not suitable for neither conventional nor GM crops. The necessary equipment for GM crops again is also specific and protected, making it unsuitable for conventional and organic crops. Conventional methods are not compatible with GM production either, due to the risk of contamination (Bodiguel 2016, 264).

The application of coexistence asks for food crops to be isolated, monitored, and have purity tests performed. It can come with the necessity for both technical as well as administrative measures, such as labeling and traceability systems. Those countries applying coexistence strategies have their own mechanisms to achieve the needed crop segregation, which is one of the primary tools to isolate crops. However, the necessary technical measures inevitably result in additional costs outside of cultivation (Kathage et al. 2015, 13). Sometimes refuge areas and machinery are needed when the prevention of pollen flow through technical measures, such as calculated isolation distance, buffer strips, and pollen barriers, are not sufficient. However, dedicated equipment is an additional cost that many less developed countries cannot afford (Vigani and Olper 2013, 34).

In addition to the technical capacity, policies are another necessity considering the different preferences between the various producers regarding coexistence applications. Cooperation between neighboring farmers can only be successful when non-technical measures, such as compensation and liability schemes, are in place. Strong organic farming presence is a dominant driver for more restrictive coexistence measures. Often organic producers and consumers tend to join forces against GM producers and attempt to prevent GM crop cultivation by intentionally asking for tight coexistence regulations. When it comes to the regulation of coexistence, Vigani and Olper focused here on the existence and stage of coexistence strategy. Even if countries already set up strategies, not all of them have enforced them or sometimes simply adopted them only partially (ibid.).

3.2.2.4. Membership of international agreements

In terms of international instruments for GMOs' regulations, the Codex Alimentarius and the Cartagena Protocol of Biosafety remain the most prevailing agreements (Hilbeck et al. 2015, 4; Vigani and Olper 2013, 34). The Cartagena Protocol emphasizes that trade considerations do not always have to come before national objectives. It primarily takes biodiversity and the environment into account next to human health (Bereano 2006, 73). The Codex Alimentarius focuses more on food safety and risk assessment as well as management despite often being referred to simply as "trade standards" (Tritscher et al. 2013, 468). The precautionary principle is considered implicit in both agreements, even though it is not explicitly mentioned in neither.

The Codex Alimentarius Commission (CAC) is a joint body established by the FAO, which contributes 14,8 percent of its funds, and the WHO covers the rest of 85,2 percent of its funds. It started developing international food safety and nutrition standards in 1961. The Codex Alimentarius itself, also known as simply "the Codex" or the "FAO/WHO Codex," refers to the collection of these food standards and related texts that were created in the following year in 1962 (FAO/WHO 2019a). For the development of standards, committees have to be consulted before the final adoption by the Codex Alimentarius Commission, which involves another multiple-tiered procedure. While the Codex in general provides ways to achieve mutual consent on safety assessment procedures for GMOs, it cannot act as a substitute for national administration. It rather offers guidance towards harmonious international trade, which the country's own law and procedures should strive to be complied with. Its main objective is to protect consumer's health and ensure fairness in food trade (FAO/WHO 2018b). These two issues are considered to be necessary due to the globalization of food trade, which on the one hand, contributes to food availability and diversification, but also increases the possibility of health and diet effects being transferred from one place to another. In the face of globalization, international standards have become even more relevant, primarily to protect consumers' health and prevent foodborne diseases and malnutrition (Tritscher et al. 2013, 468). In terms of food resulting from modern biotechnology, the Codex has two guidelines for the approach of safety assessments. It distinguishes between foods derived from DNA (deoxyribonucleic acid) - modified plants and food from DNA-modified microorganisms. In these two cases, both intended and unintended effects caused by genetic modification shall be considered as well as the possibility of allergenicity (WHO and FAO 2018, 31).

The Cartagena Protocol on Biosafety (CPB), often referred to as simply “the Protocol,” also takes risks to human health and transboundary movements into account. This protocol was adopted in 2000 based on “The Convention of Biological Diversity” and enforced three years later in 2003 (SCBD 2018). The convention focused on conservation and sustainability for the preservation of biological diversity. The protocol introduces procedures for risk assessment and management and can act as a primary policy for countries without domestic regulations for GMOs (ibid. 2000, 11). However, considering the goal is to provide a framework for countries in need, complying with its requirements comes at a high cost. Therefore, the agreement encourages developed countries to support developing countries by providing financial and technological resources that are necessary to implement the BSP (ibid., 20). It also calls for nations that deal with GM biotechnology to install mechanisms that provide an open forum for the public where information can be shared. According to Mabaya et al., these forums tend to be dominated by activists and opponents of GM biotechnology, complicating transparent dialogues (2015, 586).

3.3. Summary and Tables of AF

3.3.1. The tables of AF

3.3.1.1. Table of AF Section I: Influencing key factors before the adoption

AF Section I	Factors	Criteria	Indicators
Key factors before the adoption	Ministerial control of biosafety	• Jurisdiction over biosafety	– Number of involved departments – Responsible ministry or several departments
		• Motivation behind involved primary department	– Approach to biosafety – Interests and concerns
		• Stage of biosafety policies	– Promotion of biotechnology and its products – Risks assessments of environment and health – Involvement of stakeholder input
	Advocacy by key political figures	• View of political leaderships	– Stance on R&D in agri-biotech – Opposing or approving opinion of GM crops
		• View of other senior political figures from key departments	– Stance on R&D in agri-biotech – Opposing or approving opinion of GM crops

Table 1: Summary of AF Section I compiled by author based on Burachik 2010; Mabaya et al. 2015; Vigani and Olper 2013

AF Section I	Factors	Criteria	Indicators
Key factors before the adoption	Peer country influence	• Received influence from senior and fellow GM crop adopters • Emitted influence on pending and fellow GM crop adopters	– GM crop adopters that influenced China/Japan – Received GM policy and regulation guidance – Application of wait-and-see approach – GM crop adopters influenced by China/Japan – Emitted GM policy and regulation guidance – Application of wait-and-see approach by others
	Technical capacity	• Advancement in key industry technologies • Human resources • Financial resources	– Progress in agricultural S&T – Seed sector development – Supporting policies for innovations – Existence of NBC – Existence of other technical entities and staff – FTE of R&D personnel – Total R&D personnel (in HC) – Public initiatives for financial investments in S&T – Expenditure for R&D in GERD (in current PPP$) – Proportion of R&D expenses to GDP (in percentage)

Table 2: Summary of AF Section I compiled by author based on Burachik 2010; Mabaya et al. 2015; Vigani and Olper 2013

AF Section I	Factors	Criteria	Indicators
	Food security crises	• Natural threats to agriculture	– Resource limitations – Environmental challenges
		• Perception during challenges	– Farmers' perception – Policymakers' perception
		• Benefits of GM crop adoption	– Farmers' benefits – Policymakers' benefits
		• Barriers to GM crop adoption	– Farmers' adoption barriers – Policymakers' adoption barriers
	The role of media and activism	• Domestic media structure	– Control of media: public or private – Function of media: public service or commercial – Main target groups: farmers or consumers
		• Awareness and acceptance	– Awareness and acceptance of consumers – Awareness and acceptance of farmers
		• Debates and activism	– Source of opposition – Anti-GM activities

Table 3: Summary of AF Section I compiled by author based on Burachik 2010; Mabaya et al. 2015; Vigani and Olper 2013

3.3.1.2. Table of AF Section II: Influencing regulatory components during the adoption

AF Section II	Factors	Criteria	Indicators
Key regulatory components during the adoption	Approval process and risk assessment	• Type of main approach	– Application of precautionary principle – Application of substantial equivalence
		• Scope of approval execution	– Involved entities in approval process – Complexity for new GM crops approvals
		• Existence of AA	– Policy for unapproved GM crops – Requirement of approval renewals
		• Stage of risk assessment	– Mandatory, proposing or not existent – Focus and extensiveness of risk assessments
	Labeling and traceability	• Regime of labeling	– Mandatory basis – Voluntary basis
		• Threshold level for labeling	– Without or with threshold higher than 1% – Threshold equal or lower than 1%
		• Labeling target	– GM presence in finished product – GM technology as production process
		• Traceability of GM products	– Mandatory GMO traceability – Proposed GMO traceability – Absence of GMO traceability

Table 4: Summary of AF Section II compiled by author based on Burachik 2010; Mabaya et al. 2015; Vigani and Olper 2013

AF Section II	Factors	Criteria	Indicators
Key regulatory components during the adoption	Coexistence	• Availability of coexistence strategy • Current existing farming systems • Crop segregation measures	– Comprehensive guidelines – Not yet enforced guidelines – Absence of guidelines – Availability of organic crop farming – Availability of conventional crop farming – Availability of GM crop farming – Technical crop segregation measures – Administrative crop segregation methods
	Membership of international agreements	• Codex Alimentarius • Cartagena Protocol on Biosafety	– Signed – Ratified – Execution – Signed – Ratified – Execution

Table 5: Summary of AF Section II compiled by author based on Burachik 2010; Mabaya et al. 2015; Vigani and Olper 2013

3.2.2. Summary of the AF

AF Section I: Influencing key factors before the adoption

Ministerial control on biosafety

When accumulating data on the influential factor of ministerial control of biosafety, information on the jurisdiction over biosafety will be first determined, which is considered to be a criterion of undisputed importance among several works of researches, including indicators such as the involved ministry or other departments for GM biotechnology and GM crops (Burachik 2010; Okeno et al. 2013; Mabaya et al. 2015; Schnurr and Gore 2014). The motivation behind the involved departments is a criterion which will be ascertained and compared with each other. The stage of biosafety policies is another criterion, which can be reflected by the current and draft GM policies. According to Burachik and Traynor, a well-formulated biosafety policy framework should ideally include the following three issues: promotion of biotechnology and the safe use of its products, balanced risk assessments, and involvement of stakeholder input (2002, 43).

Advocacy by key political figures

The influential factor of advocacy by key political figures will be determined by the criteria of senior political figures' views on GM biotechnology and their intended use of GM crops. Following Leguizamón (2014) and Mabaya et al.'s (2015) works, these include the public opinions of the changing presidents and senior politicians shortly before the adoption of GM biotechnology or a new GM commodity. Their stances on R&D in agri-biotech and opinion towards GM crops are crucial, especially at the rise of the introduction of new technology and its products. The actions and stances of the ministry of agriculture and the ministry of environment play essential roles. Internal political agreement or disagreement can determine a nation's overall attitude and readiness towards GM biotechnology, which can also be reflected in the GM policies' state. Political figures can both influence the public by promoting the use of GM technology through public awareness campaigns but also find themselves on the receiving end, lobbied against by anti-GM campaigns (Mabaya et al. 2015, 585).

Peer country influence

When analyzing the factor of peer country influence, a distinction between the criteria of emitted influence and received influence can be made, while it has to be emphasized that many countries are subject to both. These two criteria are each determined by different indicators, including influencing GM crop adopting nations, the received or emitted GM policy and regulation guidance and the possible application of a wait-and-see approach by China and Japan (Mabaya et al. 2015, 582). Emitted influence on junior adopters can furthermore lead to the initiation of new adoptions, policy guidance and cause regional nations to set a benchmark for competition based on their neighbors' behavior. Possible spillover effects on the regulatory sector will also be considered, especially during the early adoption phase and the specific regulatory dimensions of labeling regime and approval process (Vigani and Olper 2013, 34).

Technical capacity

The influential technical capacity factor encompasses the criteria of advancement in key industry technologies, human resources, and financial resources. The criterion of advancement in key industry technologies includes the indicators of progress achieved in agricultural S&T, seed sector development, and supporting policies for innovations. R&D in key industries and innovation in the S&T sector reflect a nation's overall technical capacity to handle the seed sector and agricultural biotechnology, such as GM technology. In order to analyze the seed sector development, Mabaya et al. determined the stage of a seed sector by its scope of responsibilities (2015, 583). The criterion of human resources covers not only the number of persons engaged in R&D, measured in FTE of R&D personnel and researchers in R&D per million people but also the existence of NBC and availability of other public technical entities. For the financial criterion, public initiatives to promote S&T and each country's expenditure in the form of GERD in current PPP$ and R&D expenses in proportion to GDP in percentage will be determined (OECD 2015).

Food security crises

Based on Mabaya et al.'s findings, farmers' and policymakers' perceptions towards GM crops adoption will be examined for the food security crises factor. According to Burachik, especially farmers' support is crucial for adopting new agricultural biotechnology and is more easily gained by meeting their needs through simplifying agronomic practices. This usually leads to economic benefits and reduces consequences on their health and the environment (2010, 590). Since not all advantages are relevant for every stakeholder, the benefits of and barriers to the adoption of GM crops will be examined for both farmers and policymakers as determined by both Burachik (ibid.) and Mabaya et al. (2015, 587).

The role of media and activism

The most crucial criterion within the factor of influence of media on GM crop adoption is the domestic media structure, defined by the indicators including state and private control of media, the main target groups and the function of media (Vigani and Olper 2013, 37; Mabaya et al. 2015, 585). The main target groups usually involve farmers and consumers. The media's function can either follow commercial purpose or focus more on public responsibility (Vigani and Olper 2013, 37). Awareness and acceptance can be achieved through media consumption and will be examined for farmers and consumers. The influence of debates and activism is a criterion that is considered in both Mabaya et al.'s (2015) as well as Yan et al.'s (2016) studies as essential drivers of the media, involving the following indicators, including the source of debates and anti-GMO activities.

AF Section II: Influencing regulatory components during the adoption

Approval process and risk assessment

When analyzing the regulatory factor of the approval process, the first criteria is the main approach that needs to be determined, whether the precautionary principle or substantial equivalence has been applied (Vigani and Olper 2013, 33). The next step would be to examine the scope of its execution, which is characterized by the involved entities and the complexity of the approval process. The state of the approval policies and their actual enforcements are also crucial components. The phenomenon of AA should also be considered here, including additional requirements such as approval renewals and their influence on trade (De Faria and Wieck 2016, 85).

Risk assessment can be considered both an important part of the approval process as well as a crucial independent regulatory component, especially considering the continued post-approval assessments that are often required. The stage of risk assessment can be distinguished between a mandatory, proposing, or non-existent stage (Vigani and Olper 2013, 34). Furthermore, the focus of risk assessment can be decisive and often show a tendency towards either agronomical or socio-environmental emphasis, which can also further impact the extensiveness of field trial programs and determine whether they are primarily based on natural science or show an influence of societal preference (Burachik 2010, 589). Variability in technical capabilities, testing sensitivities, and the availability of a set threshold are elements that can crucially influence the outcome of a risk assessment, and along with it, a commodities' successful approval or disapproval (Ma et al. 2017, 462).

Labeling and traceability

The regulatory component of labeling can primarily be distinguished in its regime and threshold level. In the cases of both criteria I have followed Vigani and Olper's conditions by distinguishing between mandatory, voluntary, and the absence of labeling regimes. Countries with mandatory regimes can then again be distinguished in the percentage of their thresholds for labeling (2013, 34). Labeling regimes can also be distinguished in their labeling target, which can either focus on the GM presence in the finished product, or the GM biotechnology in the production process (Gruère and Rao 2007, 52).

Since traceability is often part of a requirement of labeling regimes, both will be jointly examined. It has a series of strict demands in order for it to function efficiently, including the cooperation of all actors within the food chain. Here the system of IP in each country case will be determined. I will also attempt to extract information about the involved actors as well as the system of preservation of product identity. The indicators for both criteria are based on Vigani and Olper's research (2013). The system of IP can be distinguished between a mandatory, not yet enforced or not existing system. The authors have also included a fourth score of "countries declared 'GM-free'," which has been neglected here since this research includes GMOs using countries only.

Coexistence

Following Vigani and Olper's strategy, I will focus here on the existence of coexisting farming systems and the comprehensiveness of coexistence strategies if relevant. Information on crop segregation methods, including both technical measures and administrative methods, would offer more extensive insight into this factor. Technical measures can include time, distance, and materialistic tools, such as crop rotations, specific field distances barriers for pollen flow. Examples of administrative methods include compensation and liability schemes. However, even countries with coexistence strategies in place do not always execute them consequently and can therefore also be distinguished in the extensiveness of their enforcements (Vigani and Olper 2013, 34). The availability of current available farming systems can reflect the feasibility and execution of this regulatory factor (Azadi et al. 2017).

Membership of international agreements

Considering the membership of international agreements, I will again follow the example of peers and focus on the memberships with the two most prevalent international agreements, namely Cartagena Protocol on Biosafety and the Codex Alimentarius (Hilbeck et al. 2015, 4; Vigani and Olper 2013, 34). According to Mabaya et al., most nations sign and ratify international instruments to prevent risks on human and the environment (2015, 578). Therefore, China and Japan's adherence to the beforementioned agreements will be examined through the existence or absence of signature, ratification and execution of each of the agreements.

4. Empirical Research

4.1. Influencing key factors before the adoption in China and Japan

4.1.1. Ministerial control of biosafety in China and Japan

4.1.1.1. Ministerial control of biosafety in China

China has a centralized governance system led by the State Council with all state organs under its direction. Within this governmental system, agriculture along with rural affairs fall under the jurisdiction of the Central Rural Work Leading Group (CRWLG), which responds directly to the Communist Party of China (CPC) (Gilmour et al. 2015, 79). When it comes to agri-biotech policies, China founded a Joint Ministerial Conference (JMC) involving seven different governmental agencies, namely the "Ministry of Agriculture (MOA); National Development and Reform Commission (NDRC); Ministry of Environment Protection (MEP); Ministry of Commerce (MOFCOM); Ministry of Science and Technology (MOST); National Health and Family Planning Commission (NHFPC); General Administration of Quality Supervision, Inspection and Quarantine of China (AQSIQ)" (Ma et al. 2017, 461). The JMC offers a forum for high officials from a wide range of different departments to discuss biosafety issues and examine applications of biotechnology products for approval. Another important subject for discussion within the JMC is the commercialization of GM plant varieties, including related issues, such as labeling regulations of GM plants and products or their trade policies (Gilmour et al. 2015, 79).

Next to the JMC, there are two councils that oversee agri-biotech development, namely China's National Biosafety Council (NBC), which handles biosafety issues, and the National Technical Council (NTC), which covers the standardization of biosafety management. Among the numerously involved governmental agencies, there are three major players in terms of agri-biotech and biosafety issues, namely the MOA, the MEP, and the AQSIQ. In 2016 the MEP was restructured to the Ministry of Ecology and Environment (MEE) and since then covered an increased focus on ecological protection (ibid.).

The MOA is officially appointed by the central government for the administration of the agri-biotech sector and is therefore the primary department responsible for biosafety in China. Oversight and enforcement of biosafety are subject to the MOA, which is also the department that is in charge of the development of agricultural biotechnology (Gilmour et al. 2015, 80). Within this ministry, the "office for biosafety administration of agricultural GMOs (OBA)" coordinates safety assessment of agricultural GMOs and is assigned under the Department of Science, Technology and Education of the MOA (Fu 2018). The MOA manages the applications for approval of GM crops for both import and domestic production by reviewing and issuing biosafety certificates for biotech products, including food, feed, and processed use. It is responsible for overseeing safety trials for all GMOs and has access to the Chinese government budget. In the past years, several regulations underwent revisions, allowing the MOA to outsource field trials to technical institutes that focus on biosafety. The expenses for these field trials, which used to be covered by biotech developers themselves, shifted to the government as part of these revisions. For assistance with the field trials, the MOA created the National Biosafety Committee (NBC). The NBC covers the examinations of both domestic as well as foreign applications for biosafety certificates for GMOs (USDA FAS 2017).

The MOA is the leading authority that is involved with the development of agriculture, which is a topic that has a high priority for the Chinese government. It applies policies and measures for the development of agriculture and rural areas. The main responsibility for biosafety lies with the MOA, which is the only department officially appointed by the central government to oversee the agricultural biotechnology sector (Fu 2018). Along with the focus on agricultural technology it aims to improve rural labors' quality by advancing agricultural productivity. With the help of modern agricultural production and advanced agricultural S&T, it attempts to achieve "an improved productivity of farmland, a better utilization of resources, higher productivity of labors, and a stronger overall production capability." To this end, the MOA is also authorized to distribute government funds for R&D in agricultural innovations, such as GM crops (Gilmour et al. 2015, 80). On the global level, the MOA strives to contribute to world agriculture and poverty alleviation. A current important domestic motivation of the MOA is to develop a balanced strategy for urban and rural development. Therefore, industries should be utilized to promote agriculture and urban cities to support the countryside (MOA 2019).

However, the MOA also admits current difficulties in agricultural development in China caused by the "double restrictions of resources and markets," interfering with the efficiency of development. To counteract these challenges, the current main targets include, among others, the development of modern agriculture that enables increases in grain production, agricultural returns, and farmers' incomes. In order to achieve these goals, the MOA has been raising its efforts in policy support and investments in S&T to upgrade equipment and facilities and raise farmers' cultural and scientific know-how (ibid.). Within the MOA resides a Department of Science and Technology, which is responsible for development in agri-biotech in China. It draws up strategies for S&T, ecology, environment, and rural renewable energy, and engages in the implementation and supervision of new agricultural technologies. In terms of agricultural biotechnology, it manages biosafety issues by offering policy recommendations for agricultural S&T and agri-biotech products (Gilmour et al. 2015, 80).

The second vital institution in China's agricultural biotechnology sector is the AQSIQ, another ministerial department under the State Council, and primarily manages the inspection and quarantine of biotechnology products nationwide through the local offices distributed over the country (AQSIQ 2015). This ministerial agency is also in charge of the safety of traded foods, including agricultural biotechnology products. For this purpose, it conducts risk assessments and evaluates imported and exported agricultural goods and is also tasked with preventive measures. In the case of safety or quality breaches, the AQSIQ is authorized with investigation and punishment (Gilmour et al. 2015, 81).

The third ministerial entity that plays an essential role in agri-biotech is the MEP or later the MEE, despite China's environment ministry hierarchically being ranked below the MOA in biotechnology issues. Compared to the MOA, the MEE has no decisive power and cannot veto any decisions already granted by the MOA, especially in terms of biosafety certificates. Nevertheless, the MEE is tasked with the implementation of various policies and regulations for agri-biotech development and monitors biosafety. It proposes policies with the focus on addressing environmental issues that are relevant in biotechnology development. This environmental ministry is also the leading agency in terms of the execution of the Biosafety Protocol since it is involved in the development of measures and standards for the implementation of environmental laws. Furthermore, it also engages in collecting genetic resources for research and protection purposes. Since 2016 China's environment ministry carries the name of MEE and has increased its focus on ecological protection while continuing its task of monitoring the environmental safety of biotechnologies (MEE 2016).

One of the recommended national policies on biosafety by Burachik and Traynor involves the regulatory aspect of risk assessment of GM crops and calls for a balanced approach in regards to both their risks and benefits (2002). Regulatory policies in China are not only thoroughly available but have underwent repeated revisions in recent years to increase efficiency and enable faster reviews, especially when it comes to the applications of new GM traits and products (USDA FAS 2017). China has an existing regulatory framework for GMOs, which, according to Fu, can only function with competent authorities that oversee the safety assessments of GM products. This requirement is primarily met by the MOA, which is "responsible for the nationwide supervision and administration of safety of agricultural GMOs." The "Regulations on Safety of Agricultural GMOs," drawn up by the State Council in 2001, is used as the regulatory fundament for all subsequent regulations. All biosafety related regulations, such as for safety assessments, import and labeling, are designed by the MOA based on these previous regulations by the State Council (2018). According to the ISAAA, China is known for its science-based regulation, which is a prevailing characteristic among the founding members of GM crops (2017, 44). This is also reflected in the OBA's position, which has been assigned under the Department of Science, Technology and Education (Fu 2018).

The ratified Cartagena Biosafety Protocol, which China signed in 2005 (SCBD 2016a), is another indication for a mature regulatory system in respective to the risk assessment, since the protocol involves regulatory guidelines for the safe and sustainable use of GMO food (SCBD 2000, 1). A balanced approach to both potential risks as well as benefits can be achieved through the JMC, where different stakeholders can decide on biotechnology subjects and the shared responsibility of biosafety between the MOA and the MOST. An equalized implementation of risk assessment of natural environment and human health has been attempted by considering both the benefits as well as the risks that GM crops can bring. The adoption of GM crops enabled high yields along with lower costs as well as decreased use of the more toxic pesticides, which in turn are stress-releases for both the environment as well as the farmers. According to Zhang et al., these benefits have led to an improvement of Chinese farmers' health as well as revenue (2016, 122). The reduction of non-glyphosate herbicides and insecticide played a crucial role. Despite the controversial reputation of glyphosate, it remains one of the less toxic herbicides compared to the previously used ones, which are still applied by many developing countries (Burachik 2010, 591).

The second recommended national policy by Burachik and Traynor is the promotion of safe use of biotechnology and its resulting products, which fall under the field of duties of the MOA. According to the MOA, China has entered a stage of economic development that needs the industries to promote agriculture and cities to support the countryside. The MOA is responsible for the promotion of modern agriculture, including S&T, for higher grain production and better returns. In order to achieve these goals, it utilizes policies to increase investments and enable smooth development in S&T (MOA 2019). Another promotion of biotechnology is reflected in the 13th Five-Year Plan for National Science and Technology Innovation, which was released in 2016 and proposed the goal of commercializing new GM crop generations by 2020 (USDA FAS 2017). The plan also foresees an update for the technical methods of biosafety evaluation and safety assessment of GM foods. Chinese companies are also being encouraged to invest in the biotechnology sector through improvements and transparency of biosafety evaluations and approval process (ibid.).

In regards to the call for stakeholder input, it should also be mentioned that there is a JMC established by the State Council with the focus on the safety administration of agricultural GMOs. The JMC involves officials from a wide range of different departments: “agriculture, science and technology, environment protection, public health, foreign trade and economic cooperation, inspection and quarantine.” These meetings address issues in the safety administration of agricultural GMOs and offer a forum for officials with diverse backgrounds to jointly coordinate them. Nevertheless, the main jurisdiction of biosafety remains vested in the MOA. Another entity that enables stakeholder input is the NBC, a national committee in charge of the safety assessment of agricultural GMOs. Its members are composed of experts from a bright spectrum of different professional fields, including “biological research, production, processing, inspection and quarantine, […] public health and environmental protection” (Fu 2018).

4.1.1.2. Ministerial control of biosafety in Japan

Unlike some countries that assign one specific institution for all biotech-related regulations, the Japanese government distributed the GMO regulations among several different authorities. For the regulation of GM crops, the following departments are involved: The Ministry of Agriculture, Forestry and Fisheries (MAFF), the Ministry of Health, Labour and Welfare (MHLW), the Ministry of Environment (MOE), and the Ministry of Education, Culture, Sports, Science and Technology (MEXT). These four ministries are also responsible for the protection of the environment and the regulation of lab trials (Sato 2016; Wang 2016).

In terms of biosafety, the Ministry of Environment (MOE) is the main department involved in the management of all GMOs. Depending on the GMOs' use, the MOE needs to be partnered with another ministry responsible for that specific field of use. Therefore, which ministry jointly manages the GMOs with the MOE depends on the GMOs' purpose and use. In the case of crops for commercial use, the MOE is required to be partnered with the MAFF, being the responsible department for agricultural products. "Viruses for gene therapy" are covered by the MOE partnered with the MHLW and "field experiments for research" by the MOE partnered with the MEXT (Alien species and LMO Regulation office et al. n.d., 8).

Among these four ministries involved in biosafety jurisdiction, the MOE remains the only one covering all issues concerning GMOs in cooperation with a second responsible ministry being either the MOE, MAFF, or MEXT, depending on the use of the GMOs. In the case of this thesis, which focuses on GM crops, the cooperation of MAFF and MOE covers exactly these commodities. In general, the MOE is responsible for environmental planning and implementing policies that follow the Basic Environmental Law of 1993 (AECEN 2018). The MOE incorporates a broad spectrum of environmental laws, such as the Biosafety Protocol (MEXT 2006).

One of the MOE's primary tasks is to promote environmental policies by proposing practice-oriented mechanisms and ultimately reaching sustainability in society. In order to accomplish this goal, the MOE actively supports environmental policies within the government, especially on the issues of "waste management, pollution control, nature conservation and wildlife protection." The MOE is also one of the most collaborative ministries in Japan and jointly establishes with other ministries measures focusing on "global warming, ozone layer protection, recycling, chemical management, marine pollution control, forest/vegetated land/river/lake-wetland conservation, environmental impact assessment and the monitoring of radioactive substance" (AECEN 2018). The MOE's high level of cooperativeness is also reflected in its willingness to collaborate with partner institutes to promote R&D, both on the national level, through the National Institute for Environmental Studies (NIES) for conservation technology, as well as on the international level, via the Institute for Global Environmental Strategies (IGES) for the promotion of sustainable development in Asia-Pacific region or the Pacific Network for

Global Change Research (APN) for global research. To expand cooperation and increase human resources, the MOE provides training courses for governmental specialists (ibid.).

For this research, the MAFF is one of the most relevant ministries since it houses specific crop biotechnology decisions. The MAFF's motivation is both straightforward as well as comprehensive. On the one hand, this ministry primarily covers the administration of agriculture, forestry, and fisheries. On the other hand, it is also engaged in related issues to these industries, such as the production and consumption of their products. Its goal is to advance the sectors it is responsible for and use their development "to promote the harmonious development of economic society and stability of national life." The MAFF covers a wide range of adjoining issues as well, such as food security, including a stable supply of food, and its maintenance through the beforementioned industries (MAFF n.d.).

One of its primary goals is to reach a balance between import and domestic production of agricultural products. The MAFF aims to achieve stability and development of the national economy through the agriculture, forestry, and fisheries industries. These sectors are utilized to offer a stable supply of food and natural resources for the population's daily lives (MAFF 2015, 4). In its report for 2017, the MAFF counted the assurance of food safety and consumers' confidence as part of its responsibilities. In terms of GM foods, it is noteworthy that the MAFF oversees the enforcement of labeling regimes, including GM foods and, if necessary, their revisions as well (MAFF 2018, 18). GMOs belong to one of the major research subjects in life sciences with the "Assurance of Safe Use of Genetically Modified Organisms" as one of their primary devices and fall under the responsibility of MAFF as well (MEXT 2006, 233).

The MHLW's mission is "to build a society that ensures lifelong security of each and every person." This ministry promotes several measures to achieve this mission, such as medical care, health promotion/disease control, drug, and food safety, improvement of employment, labor standards, support for the young, elderly and people with disabilities, and more (MHLW 2018, 5). Each sector is overseen by a bureau for its responsible field. Food safety falls under the task of "Pharmaceutical Safety and Environmental Health Bureau" within the MHLW, which aims to accomplish safer lives by formulating food standards, improving conditions of the natural environment, and providing life-essential resources, such as safe tap water. The MHLW also aims to achieve food safety by "flexibly responding to progress in food-related science and technology, globalization of food distribution, and diversification of dietary habits, etc."

Corresponding to this statement, the MHLW has adopted a relatively open attitude towards advancements in agri-biotech and its products (ibid., 11).

The MEXT is responsible for the areas of education, S&T, sports, and culture. When it comes to GMOs, the administration of S&T is most relevant. This area involves the development of S&T, including shaping policies that encourage technological advancements and promotion of social acceptance towards new technology. The basic policies for the S&T administration are established by the Council for Science and Technology Policy (CSTP) and involves the promotion and advancement of S&T primarily. The MEXT manages the planning of basic S&T policies and their execution. It formulates specific strategies for the advancement of S&T, including R&D, and interdepartmental coordination of their execution with other related ministries (MEXT n.d.). In order to support academic research, it assists research organizations and designates research grants for them. The main objective of the MEXT is "becoming the world's most innovative country." To achieve this goal, the MEXT conducts assessments on domestic and international trends in S&T. This ministry is also responsible for the evaluation of R&D based on its own formulated guidelines (ibid. 2016, 14).

S&T policy in Japan is administered by the S&T Basic Plan and updated every five years. According to the most recent Basic Plan, "ensuring stable energy, resources and food" and more specifically, "securing a stable food supply" remains an important issue for not only the S&T administration but also the MEXT (Cabinet Office, GOJ 2016, 20). In one of their latest S&T Basic Plan, the Japanese government addresses the nation's current pressing issues, including energy, resources, declining birthrate, aging population, and also food limitations. With increasing population, food and water are becoming scarce in the long term**.** Japan sees itself as "an Asian country with the most advanced S&T" and part of its responsibility to overcome these very challenges in food production and water resources (ibid., 4). In order to ensure stable supplies of the beforementioned commodities, including food, the Japanese government aims to decrease its current heavy dependency on foreign suppliers (ibid., 20).

Japan is renowned for its pragmatic approach towards biotechnology and its products (Ma et al. 2017, Wang 2016). It is one of the first countries that has signed the Cartagena Act and used it to regulate GMOs that occur in food. As mentioned before, the Cartagena Act is the law that regulates the application of GMOs. It enables the correct application of the Cartagena Biosafety Protocol by offering rules for risk assessments and sustainable use of GMOs (Alien species and

LMO Regulation office et al. n.d., 6). By signing and quickly adopting the Cartagena Act into its domestic law for biosafety alone, Japanese law already incorporates one of the three recommended national policies on biosafety by Burachik and Traynor (2002), namely risk assessment for both the environment as well as human health. The regulatory aspect of risk assessment in Japan will be illustrated more detailed in its own section in chapter 4.2.1.2.

The second recommended national policy on biosafety includes the promotion of biotechnology and its safe use, which Japan again fulfills primarily led by the MEXT. In Japan, S&T policies follow the rules set up in the S&T Basic Plan. Especially its first plan of 1995-2000 showed its "technology-first approach" by following global trends, such as the enthusiasm for biotechnology, nano- and health technologies (Holroyd 2014, 7). By following the first S&T Basic Plan, the MEXT is by default involved in the promotion and advancement of S&T, including GM biotechnology (MEXT n.d.). Unlike the MEXT, whose devotion towards biotechnology is innate in its purpose, the MAFF's and the MOE's support for GM biotechnology depend on their stance towards the very subject and whether they each consider this technology to forward their objectives, which is national stability for the first and sustainability in society for the latter. In general, the Japanese government strives to use biotechnology to aid its economic growth, which has been an important part of Prime Minister Abe administration's strategy. The Ministry of Energy Trade and Industry (METI) is focusing on a "biotech-based economy" by promoting the development of these technologies, including biotechnology (Rodergas 2018, 15).

The involvement of stakeholder input is the third recommended national policy by Burachik and Traynor (2002, 43). The MOE organizes "Stakeholders' Meetings" in order to promote sustainable development goals. Although these meetings have a strong environmental emphasis, they also include agricultural production, among many other areas connected with environmental issues. Stakeholders from a wide range of different fields are among the participants representing private companies, local governments, and NGOs. At these meetings, the Japanese government, represented by the Ministry of Foreign Affairs and the Cabinet Office, and the companies share their progress and techniques in the attempt to achieve sustainable development. According to the MOE, improvement of crop varieties and a shift of cultivation areas are being encouraged not only from the environmental perspective but also for the development of new markets and to revitalize communities (2018, 3).

A specific policy promoting this exact issue could not be discovered, although there are scholars that detect advantages for all stakeholders in Japan's "pragmatic, evidence-based approach" to the commercialization of GM biotechnology and its products (Ma et al. 2017, 465). By adopting a strong scientific approach, which primarily affects approval regulations and risk management, Japan enables smooth trade with fewer disruptions. The scientific-based regulations and their positive impact on trade are incentives to stakeholders, such as innovators or entrepreneurs. This approach might have been applied out of both economic pragmatism and courtesy towards stakeholders as well as a necessity due to Japan's high dependency on food import (ibid., 466).

4.1.1.3. Intermediate results of ministerial control of biosafety in China and Japan

The main difference between the two East Asian countries' jurisdictions over biosafety lies in the leading institution for biosafety matters, which is the MOA in China and the MOE in Japan. Both China and Japan's administration support the development of agri-biotech at the rise of its implementation in the agriculture sector. They share a pragmatic approach based on science and set the development of biotechnology as a priority in their national strategies (ISAAA 2017, 44; Ma et al. 2017, 465). This approach is also influenced by the similar motivation behind the leading institutions, which covers in both countries the growth of agricultural productivity with sustainable development in the long run (MOE 2018, 3; MOA 2019). Despite the involvement of several governmental entities in each country, China and Japan beat the unfavorable odds predicted by Mabaya et al. (2015, 581), and showed efficiency in the promotion of biotech R&D through clear allocation of leadership and regular meetings as platforms for information exchange.

4.1.2. Advocacy by key political figures in China and Japan

4.1.2.1. Advocacy by key political figures in China

The advocacy of Chinese leadership for biotechnology played a crucial role in establishing a supportive environment for its development. According to Falkner, China's biotechnology programs date back to the 1970s when the country encouraged economic modernization programs. The advancement of technology was considered a crucial element for the overall development in China, including computer science, space technology, and biotechnology. The

Chinese leader Xiaoping Deng notably advocated for genetic engineering along with the beforementioned technologies and incorporated GM biotechnology into his reform policy in the early 1970s. In the 1980s, genetic engineering was officially considered as an essential part of China's national agricultural strategy (Falkner 2006, 476). Deng approved the National High-Tech R&D Program, the 863 Program, which was managed by the MOST since 1986 and implemented by the successive Five-Year Plans (Gilmour et al. 2015, 75; MOST n.d.a.). The promotion of biotechnology development was an important component and rose through the 863 Program to one of the strongest state-funded research programs (Newell 2008, 119).

Overall agri-biotech development remained consistent with China's national interests and was supported through the 1990s by the nation's leaders. One of them was then Chinese Premier Rongji Zhu, who proclaimed at the National People's Congress in 1999 that China "should work vigorously to develop agriculture through science and technology" and "accelerate the work of breed selection and improvement and spread the use of advanced, applicable techniques which can increase production and income" (Newell 2008, 119). With the approval of politicians like Zhu, China became a leading developer and promoter of biotechnology in the 1990s, a time with the highest consensus on this issue. In contrast, the 2000s were characterized by uncertainties and inconsistencies both within as well as outside of the government (ibid., 120).

The absence of safety regulations for GM biotechnology was advantageous for Chinese researchers in becoming the first to successfully grow GM tobacco plants with virus resistance in commercial quantities (Falkner 2006, 477). Domestic environmentalism rose only in the 1990s under the leadership of President Jintao Hu, who repeatedly emphasized the importance of sustainable development. Sustainability rose to a guiding principle promoted by the Hu leadership, which initiated the first steps towards establishing a safety regime for biotechnology in the early 2000s (ibid.).

Due to scientists' frequent high-level access, their influence on the central leadership were gradually growing and reflected in high-profile politicians' statements. One example would be from Premier Jiabao Wen, who stated in an interview in 2008 that he "strongly advocate[s] making great efforts to pursue transgenic engineering" while referring to the domestic benefits GM cotton had brought, such as increased yields through bollworm resistance, and addressing GE's contribution to food shortages on both the national and global level. In reference to

Europe's aversion towards this technology, Wen remarked not to mix transgenic science with trade barriers, since this would block the development of science (Xin and Stone 2008, 363). In 2010 he continued his advocacy towards GM crops and emphasized the necessity of innovation and adoption of new agri-biotech as well as the creation of new crop varieties with the help of transgenic technology (Cao 2019, 57).

Under the leadership of President Xi and Premier of the State Council Keqiang Li three relevant policy documents were released, including the "National MLTP for Cultivating Biotech Talents (2010-2020)," "the 12th Five-Year Plan for Development of Biotechnologies" conducted by the MOST and "the 12th Five-Year Plan for Agricultural Sciences and Technology Development" presented by the MOA (Gilmour et al. 2015, 77). The first policy addresses China's college-graduates, who will reach the number of 195 million by 2020. In order to efficiently utilize this upcoming large amount of educated human resources, this policy is supposed to attract these millions of students to six broad sectors, including the field of technical professionals. It is considered to be an important measure for China's goal towards becoming an innovation-driven economy (ibid.).

President Xi even signaled cautious support for the commercialization of GM crops already in 2014 when he claimed that he would "take the commanding heights in biotechnology, and not let large foreign companies dominate the agricultural biotechnology product market" (Hvistendahl 2017, 17; ISAAA 2017). According to Ma et al., Xi had announced biotechnology as a "promising new technology with potential for benefits in society and for the economy" (2017, 460), and his regime actively supported the relevant research (Huang 2018, 149). He encouraged innovation of domestic technology while emphasizing the importance of biosafety. Despite supporting the advancement of biotechnology overall, the Xi administration continued to monitor and control the licensing and commercialization of biotechnology strictly. A crucial reason for this behavior was to prevent large firms from dominating agri-biotech market (ibid.). According to ISAAA, Xi started actively supporting the R&D of not only agri-biotech, but specifically GM crops since 2015, such as "strong research and innovation" on GM crops." His stance on GM crops is also reflected in the 43 billion dollars bid from ChemChina for Syngenta in 2015 (2016, 44). Subsequent to the bid, 14 biotech crops were reapproved by the MOA and extended to 2020 (Clive 2015, 10). The acquisition of Syngenta by ChemChina was completed in 2017 with the government's support and contributed to China's GMO policy (Cohen 2019).

Xiwen Chen, a deputy director of the Central Leading Group on Rural Work, is another important political figure that advocates for the advancement of agri-biotech. The beforementioned leading group governs jointly with the CPC rural economy and agriculture, including agri-biotech. Several analysts believe that Chen would remain an active advocate for agri-biotech development in the future as well (Gilmour et al. 2015, 79; Cao 2019, 48). In a news conference in 2013, Chen confirmed the large amounts of imported soybeans of which the majority is GM and emphasized their importance for both oil extraction for human consumption as well as their function as plant protein in the feed industry. Chen also addressed the safety concerns for GM crops, while admitting that there is no possibility to guarantee absolute safety for the consumption of GM crops, which is also applicable for any other crop variety that humankind has developed throughout the history of agriculture (Guo 2013).

Jun Han is another deputy director in the leading group like Xiwen Chen, who called for the advancement of both agri-biotech as well as GMO biosafety. Han advocated in 2015 at a press conference to strengthen research on agri-biotech and GMO's biosafety based on the environmental and resource challenges, especially in the face of feeding China's large population. He saw in transgenic technology the future for new industries and emphasized China's role as one of the founding nations of biotech crops, which allowed the country to maintain its leading position in the research of GM rice and GM corn (Cao 2019, 48). Since 2016, Han also focused on the importance of "consumers' right to know and to choose" and adapted his role to a figure addressing civic concerns by adding "his deep understanding of public concerns about GMOs" to his advocacy of transgenic technology. While admitting the global controversies around GM crops, he also addressed the international consensus on the safety of approved GM foods since those underwent rigorous safety assessments and had to pass the approval process with high standards. Despite recognizing and responding to public concerns, Han still emphasized that China's national policy for transgenic technology had to remain consistent and even pointed out that "transgenesis should be recognized as a scientific issue, which might not be quite comprehended by those who are not involved in the research" (ibid., 49).

Zhangliang Chen is an example of the importance of having members with technical know-how in the government and reflects the benefits that come along the strong tradition of overseas training. Even though China belongs to the pioneers of GM biotechnology, the leading research institutions, especially in the rise of high technology, are located in the US, Europe, and Japan.

As one of the oversea Chinese students with a transgenic science major, Chen was among those who profited from China's reform and opening era, which occurred around the same time as education and research started globalizing. Chen is considered one of the pioneers and most essential advocates for GM plant research. His work created in 1992 the first GM crop for commercial production, which is GM tobacco. After becoming a bureaucrat, his influence in the science field declined, although he continued to represent and vanguard the pro-GMO faction even after becoming a member of the Standing Committee of the Eleventh and Twelfth Chinese People's Political Consultative Conference (CPPCC) (Cao 2019, 60).

The development of agri-biotech needs a supportive policy environment, which can only be provided if there is vivid interaction between scientific and political leadership (ibid., 55). The Chinese political leadership has taken this factor seriously by regularly inviting academics and scientists to update its members with genetic engineering and biotechnology know-how. Qifa Zhang is a leading plant geneticist, and like Huang, a CAS member, who lectured the government's leading group for S&T on GM foods and the technology behind it. Inspired by this lecture, the then Premier Zhu announced his support for an increase of investment in the S&T sector and confirmed his advocacy for commercial production of GM crops in early 2001. However, during the following years, Zhang was also known as a leader of a group of scientists and experts from economic and food-safety fields to criticize the government's rigid regulations for GM crops, especially the overly strict and lengthy approval processes that compromised the development of transgenic technology in China (ibid., 46).

4.1.2.2. Advocacy by key political figures in Japan

Japan's affection for the promotion of S&T dates back to the Meiji era and biotechnology since the 1970s. Debates concerning transgenic techniques were launched in 1975 under Prime Minister Miki Takeo and continued in 1979 under his successor Ohira Masayoshi. Since 1980 Japan officially identified biotechnology as one of its priorities for economic growth, and the government started supporting the R&D of GMOs. One of the first Japanese prime ministers who openly advocated for GM crops in Diet negotiations is Hashimoto Ryutaro. During his term in 1996-1998, the first GM crops, including corn, soy, and canola, were imported from the US and Canada in 1996 (Tiberghien 2006, 28). However, already in early 1997, GMO civil society movements in Japan emerged and lobbied successfully in the following years against local governments and even reached to the central government by the turn of the century

(Nishizawa and Renn 2006, 46; Tiberghien 2006, 27). The MAFF and Ministry of Health, the two ministries in charge of GMO regulations, were increasingly under pressure through the petitions and actions by public campaigns, which led to the MAFF's move towards mandatory labeling in 1999 (Tiberghien 2006, 28).

Despite the protests in the periphery, the central government remained initially uncompromised in terms of its national course, which provided room for advocators to support the development of biotechnology and GM crops from within. A crucial politician for the development of agri-biotech in Japan is Omi Koji from the Liberal Democratic Party of Japan (LDP). He was considered as the leader of the biotechnology lobby in the government and assigned by Prime Minister Mori Yoshiro personally from 2000-2001 with the task of promoting biotechnology in Japan. Under Prime Minister Koizumi, he was appointed to the Minister of Science and Technology. With Koizumi's full support, Omi Koji was able to launch crucial promotions for the advancement of Japan's biotechnology. He established the Biotechnology Strategic Council intending to catch up with the US and Europe in biotechnology and created the Science and Technology in Society (STS) forum for open discussions of S&T. Koji gave speeches at these events, in which he emphasized Japan's important role in biotechnology R&D and industrial development (Tiberghien 2006, 26).

One of the more recent Japanese leaders who showed advocacy towards biotechnology was the previous Prime Minister Junichiro Koizumi. The former prime minister was involved in several policies for the advancement of biotechnology, as evidenced in various strategies and policies he initiated, such as the "White Paper on Science and Technology 2006" (MEXT 2006). It was Koizumi's decision and consent to create the Biotechnology Strategy Council in 2002 and acknowledge the impact of biotechnology on "the improvement of people's lives and the enhancement of industrial competitiveness" (Cabinet Public Relations, Office Cabinet Secretariat 2002). In order to achieve these goals, it was decided to establish the earlier mentioned council to advance biotechnology strategies in Japan. The council consists of "Prime Minister, the Chief Cabinet Secretary, the Minister of State for Science and Technology Policy, the Minister of Education, Culture, Sports, Science and Technology, the Minister of Health, Labour and Welfare, the Minister of Agriculture, Forestry and Fisheries, the Minister of Economy, Trade and Industry and the Minister of the Environment" and other experts. In the course of this council, the prime minister announced "to pursue the biotechnology strategy as one of the top priority issues for Japan" upon receiving them in his official residence. The

Biotechnology Strategy Guidelines compiled by the council aimed to achieve the three main practical issues of utilizing biotechnology to enhance R&D and industrialization, and improve people’s lives (ibid.).

In 2002, during Koizumi’s second year into his term, an important policy update on the general support for biotechnology was implemented, which included a reorientation of government funding agencies for new innovative technologies. The MAFF under its minister Tsutomu Takebe in Koizumi’s cabinet remained supportive towards the research of crops genome, especially for the food crop rice, and received a subsidiary, the “National Institute of Agrobiological Sciences (NIAS),” which is the leading institute responsible for the research and promotion of GM crops. In 2016 the NIAS was reorganized and incorporated into the NARO (Watanabe et al. 2005, 516).

The latest prime minister that showed some signs of following in ex-premier Koizumi’s steps was Shinzo Abe, represented in his “Abenomics,” which is a collection of new economic policies and growth strategies aimed to stimulate and restore Japanese global competitiveness (JapanGov n.d.a.). The restoration of a competitive biotechnology industry is part of these measures by investing in R&D that should lead to more innovation. One vector in this program is “Smart Regulations & Laws,” which aims to ease regulations, such as shortening approval process for innovative technologies, for a limited time frame to support its R&D, especially in the early phase of a novel adoption (JapanGov n.d.b.). The approval process, especially for food products resulted from biotechnology, has to undergo strict and lengthy measures. Therefore, Abe’s measure in this field increased efficiency in the developments of the biotechnology sector as well. In this context some exceptions for test requirements for selected GM foods have been lifted, such as for GM corn (Sato 2016). However, there is no evidence for the prime minister’s stance on GM crops or agri-biotech specifically. His policies were increasingly shifting the use of biotechnology towards medicine treatments and the biopharmaceutical industry (Kawano and Matsuyama 2013; The Biotechnician 2015).

Satoru Morishita, the current Director General of the Global Environment Bureau in the MOE, stated the importance of the advancement of crop varieties and the diversification of cultivation areas, especially in the face of climate change. According to his statement, “a single solution can often result in improvements in multiple priority areas. The MOE holds the Stakeholders’ Meetings to share and disseminate such information in order to raise awareness of the ripple effects." Based on this theory, he is convinced that the improvement of crop varieties and the advancement of biotechnology would incidentally also lead to the development of new markets and revitalization of the Japanese economy and society, which again would lead to higher efficiency and competitiveness (MOE 2018, 3).

Hiroshi Satoh, the Chairperson of the Food Safety Commission of Japan (FSCJ), advocated for science-based risk assessments especially for new food varieties. The FSCJ is responsible for food safety to human health, and since most GM plants also fall under food crops, they belong to the responsible domain of the FSCJ as well. Since Satoh's approach towards the effects of food on human health was solely based on science, his stance on GM foods was also characterized by this approach. Satoh saw similarities between the purpose of GM food and the purpose of pesticides and additives since they all aimed to ensure food productivity and food quality. The underlying principle of the FSCJ is science-based measures for food safety, which is represented primarily by Satoh. He considered "risk communication" as part of the FSCJ's responsibility, which is a tool to provide the results conducted by previous risk assessments in a correct and easy-to-understand-manner. This approach is also reflected in Satoh's stance toward GM foods, which he considered from their scientific and pragmatic perspective. With biotechnology and GM foods, many new possibilities have been created, including increased volume and variety of food. However, the surge of variety and amount of food leads to an increase in the food trade, causing possible food risks with the rising potential of global spreading if not controlled efficiently (FSCJ 2015, 1).

Takamori Yoshikawa is Japan's previous minister of agriculture and stated the importance of innovation in agriculture and the advancement of agricultural technologies in the most recent G20 meeting in 2019. Raising food production efficiency through the advancement of technology in agriculture is crucial for Japan, due to the country's rapid population decline and the aging of society. It would contribute as an incentive to attract younger people in joining the agriculture sector, where the share of aging workers is high among farmers. For young people to get interested in farming again, it has to become profitable, which can be achieved through market access and new technologies (Johnston 2019).

Pressure on Japanese politicians increased at the turn of the century. The Japanese government seemed to be more susceptible to its consumers' disapproval and farmers' resistance. Civil society groups consisted of influential leaders who focused on health safety, transparency issues, and environmental concerns (Nishizawa and Renn 2006, 48). Bonded by these issues, they shared a united front that forced political leaders to take regulatory measures in order to defuse the growing protest and prevent civil crisis (Tiberghien 2006, 27). These groups in Japan were known to be well-organized and reached massive petitions through consumer cooperatives. Grassroots member organizations were mobilized to lobby against local governments. Over the years, they grew strong enough even to influence voting intentions. Criticism towards those Japanese politicians, who supported agri-biotech since the turn of the century, even caused some key mainstream politicians to shift position and join non-mainstream politicians, who were against GMOs, to prevent losing votes (ibid. 2012, 116).

4.1.2.3. Intermediate results of advocacy by key political figures in China and Japan

Leading politicians in both countries have been overall well disposed towards the advancement of biotechnology in general, although they differ in their enthusiasm for the specific areas of agri-biotech and GM food within the biotechnology sector. While most Chinese political leaders have been continuously advocating for both agri-biotech in general, as well as GM biotechnology and specifically its products since the 1970s (Hvistendahl 2017; ISAAA 2017; Huang 2018), Japanese politicians adopted a more cautious approach due to strong civil society movements (Yamaguchi and Suda 2010, 393). This is reflected not only in their growing interests towards biotechnology for the health sector but also in the overall absence of public advocacy for specifically GM biotechnology in the recent years. Unlike the limited interest of Japanese leaders in GM biotechnology, the Chinese leadership not only publicly recognizes but actively advocates for it as a primary tool to ensure domestic food security and to face domestic environmental and resource challenges (Cao 2019, 60; Gilmour et al. 2015, 79; ISAAA 2017, 44).

4.1.3. Peer country influence in China and Japan

4.1.3.1. Peer country influence in China

Since China is among the pioneer countries, there are only a few that could have had influenced it from a more senior position. The first commercial GM plant, namely transgenic tobacco, was produced in 1992 in China, although it has to be admitted that its cultivation was only for seed research and multiplication purposes. The first GM crop for food consumption was grown two years later in the US in the form of transgenic tomatoes with the GM feature of slow ripening. In the following three years, more crop varieties, including canola, corn cotton, and soybeans, were initiated in the US and Canada. Both of these two North American countries now have over twenty years of experience in GM crop production and regulation (Smyth 2014, 195) and also had an influence on China's rise in this sector. In overall agri-biotech cultivation, China ranks sixth in the world after the US, Brazil, Argentina, Canada, and India (Gilmour et al. 2015, 72), all of which belong to the early adopters (Scandizzo and Savastano 2010, 142).

Especially in the context of regulations for GM crops, China followed the example of those countries with more advanced regulatory frameworks already in place, despite its role as one of the leading agri-biotech developers. For the design of China's own risk assessment process, Chinese officials compiled elements from a variety of different approaches adopted by fellow GM crops using nations, such as the US, Japan, and the EU. International institutions, including the OECD, the FAO, and the WHO, also played crucial roles. For example, China's approach to the precautionary principle was based on the EU's example in terms of approval and labeling process. This approach, however, represented a great inconvenience for North American exporters and caused for their criticisms against China (Newell 2008, 124).

The US is one of the few prominent GM biotechnology users with seniority over China, although both nations currently represent large markets for GM foods. The US tried to influence China, especially in order to achieve favorable economic terms for itself, similarly like its approach to the EU. For example, US trade officials have been trying to convince China to adopt a less complex and more straightforward approval process, using its own single-agency approach based on the Food and Drug Administration (FDA), which deals in the US with all approvals. Especially in the past did the US often express their preference for China to mirror their administration of the approval process for commercial purposes. Even though politics of biotechnology are known to be prone to pressure from foreign countries, especially trade partners, China did not adapt their administration towards the US recommendation but instead moved closer to the EU (Newell 2008, 126). In terms of trade, China had to invest extra effort in convincing the US that its domestic regulations for GM crops were not intended to be discriminatory towards the US exporting shipments (ibid., 134).

China’s cautious approach was caused not only from domestic concerns but also from outside skeptics. The European countries were particularly renowned for their skepticism towards the GM crops’ safety and tended to reject whole shipments when facing contaminations from GM ingredients. Since Europe remained a crucial market for China’s food export, their rejections of China’s shipments were viewed as the decisive factor for China’s labeling restrictions. The direct cause was the United Kingdom’s (UK) rejection of China’s soy sauce due to its containment of GM ingredients from the US. A similar incident occurred in 2006 when traces of illegal GM rice were detected in food products that were imported from China. The resulted temporary trade bans by the EU contributed to China’s reluctance to approve GM soybean and approach to the precautionary principle favored by Europe, thus, moving farther away from North America’s substantial equivalence. Therefore, China had not lost its interest in biotechnology, but simply tried to protect domestic producers and biotech enterprises by shifting its position (ibid., 120). Despite this regulatory shift, the US still managed to circumvent China’s new biosafety rules from through diplomatic pressure, leading China to issue not only interim but also formal safety certificates for American soybeans by 2004. This experiences back in the early 2000s showed the developing world the difficulties for less powerful trading partners in implementing biosafety rules (Gupta and Falkner 2006, 41).

During the 1990s already, China was one of the leading developers and promoters of agricultural biotechnology (Newell 2008, 120). In terms of IR cotton, China had been one of the leading countries since 1997 (ISAAA 2017, 42). China did not necessarily inspire other countries to adopt a specific commodity, as Mabaya et al. have concluded based on the cases of African countries and their adoption of GM crops (2013), but instead provided them a reason for the adoption of GM crops in the form of source for income. This is much the case for several South American countries, most prominently for Argentina and Brazil.

Leguizamón referred to GM soy as “the goose that lays the golden eggs in Argentina,” which helped revive its economy. Argentina rose to the third-largest grower and exporter of soybeans, with China as one of its stable markets. It shipped 83 percent of the soybeans it produced to China alone in 2010 (2014, 152). China’s increasing food demand next to India’s represented more benefits for its exporters, which became the reason why Argentina adopted and expanded its “GM soy based agro-export model” (ibid., 155). Brazil is one of the main suppliers for soybeans since it is the preferred crop by Brazilian farmers and shows high demand as well as profitability. Similar to Argentina, Brazil had also found a steady export market in China, especially considering the its strong demand for this crop in the food and animal meat industry (ISAAA 2017, 17).

India would be another example of the influence China emitted as a peer country in agri-biotech, especially GM technology. Up to date, China and India both gained long experiences with this technology's promotion and development stretching over several decades. However, in the 1990s, China was ahead of India. According to Newell, back then, India made use of the idea of China's role as a "biotech "super power"" with the help of media in order to emphasize the importance of agri-biotech and convey its potential. The need to keep pace with China was supposed to encourage the advancement of India's own biotech sector (Newell 2008, 121). Some Indian investors applied the "wait and see approach" mentioned by Mabaya et al. (2015), which Newell referred similarly to as "waiting and watching" of investors in order to predict and influence the government's moves. By first finding out the government's stance on approvals for specific commodities, investors can pressure the government to speed up the necessary approval process and achieve approval at favorable times (Newell 2008, 121).

However, the "wait and see approach" can lead to time delays, which can be crucial for a country's position in the international market. Some researchers criticized India's beforementioned approach that led to procrastination and caused the country's omission to occupy the GM cotton supremacy which became reserved for China. Governmental officials with a pro-biotech stance even used to cite the advantages of agri-biotech based on examples from China's farming experience. These advantages included reductions of pesticide usage and harmful environmental effects caused by them and benefits, especially for small farmers, such as lower costs from pesticide reductions and higher yields from more resilient crops. However, there was also the argument to which extend the Chinese model for agri-biotech adoption would be applicable to India, considering the differences of these two countries' capacity for R&D and contrasting roles of civil society in biotechnology. Other Indian advocates for GM biotechnology criticized domestic regulatory inefficiency and indecisiveness that caused the nation its chance to surpass China when India was handling a reintroduction of cotton in the 1990s (ibid.).

Africa would represent another region endemic to developing countries subject to the strong influence and pressure from the Europeans and Americans. However, scholars like Paarlberg, strongly encouraged them to look for alternatives to enable independent choices of their own, especially in terms of GM crop regulations by citing China as an example for developing countries that "operate relatively free from external influence." China discovered strong value in GM biotechnology at its rise, and the vast public investments of financial resources for the R&D of this technology for domestic use rewarded them with benefits, that Africa should follow (Paarlberg 2010, 612).

There is an argument that if China has found ways to benefit from experiences of developed countries, such as the EU and the US, so can other developing countries with potentials in the agri-biotech sector, such as India, Bangladesh, and Africa (Jiao et al. 2018, 761). China's achievements and benefits through GM crops was regularly used as an example to encourage other developing countries to follow suit in order to reach similar results (Newell 2008; Paarlberg 2010; Jiao et al. 2018). While Africa should decide on its own which approach and GM commodities would be beneficial to adopt, several countries of the continent already aimed to achieve similar breakthroughs and success through agri-biotech and GM crops like China. Currently, Burkina Faso, Egypt, South Africa, and Sudan have commercialized GM crops (Mabaya et al. 2015, 579).

4.1.3.2. Peer country influence in Japan

Japan also belongs to one of the pioneer countries in terms of the research and adoption of biotechnology. One of the reasons for this early achievement is its ambitious goal, officially noted in its First S&T Basic Plan for 1995-2000, to catch up with the West in its R&D investments and prioritize technological advancement (Holroyd 2014, 7; Cabinet Office, GOJ 1996). Among these modern western countries, Japan especially took note of the technological advancement of the US and attempted to not only duplicate but surpass its results. The goal of reaching the same level as modern Western countries had been one of the repeating mantras in the S&T Basic Plans that required Japan to meet the spending target of 3 percent of GDP for R&D expenditure (Cabinet Office, GOJ 2001, 19; ibid. 2006, 3). This ambitious target was finally met by 2002 (World Bank 2019a). The US did not only have a spurring effect on Japan's biotechnology sector but also offered itself as a cooperation partner, encouraging Japan's advancement in seed development. These two of the most experienced countries collaborated first in 1989 already for a joint project for the R&D of new seed varieties (Yamaguchi and Suda 2010, 391).

However, in terms of regulatory aspects, Japan leans closer to the European approach, as opposed to Paarlberg's predictions (2010, 612). Based on the author's theory of external cultural influence on a country, Japan should have succumbed to the US's influence and followed its lead in issues of commercialization and regulations of GM crops. Examples would be Latin American countries that traditionally lie in the sphere of influence of the US, or the Philippines, which is the only Asian country having approved GMO maize and also a former American colony (ISAAA 2016, 61). However, despite the US's influence, Japan favored the EU's approach, which is closer to its domestic needs by taking civic concerns into account, and adopted it accordingly for its approval process and risk assessment (Wong and Chan 2016, 127).

Since Japan belongs to one of the first countries with advanced regulations for biotechnology and GM commodities, its regulatory framework has regularly been used by other countries as a reference when establishing their own. Japan launched discussions of GM biotechnology already in the 1970s and formed its first guidelines for GM technology by 1979. Afterward, these underwent several revisions and became the fundament of the subsequent rules for R&D of GM biotechnology in Japan. These early regulatory preparations helped Japan to apply the adopted technology easily in other related fields, such as medicine, industry and agriculture (Shineha and Kato 2009, 142). Countries like China witnessed Japan's success and borrowed elements from Japan's regulations for its own, such as Japan's risk assessment process (Newell 2008, 124).

Japan also actively participated in the expansion of commercial soy production in South America. The Japanese immigrants were among the people that brought soybeans to South America during the first half of the twentieth century, especially in Brazil, Paraguay, and Argentina. All three countries rose to major producers of soybeans (Oliviera and Hecht 2016, 253). GM crops were first introduced between 2003 and 2005 in Brazil, Paraguay, and Bolivia. In 2016, GM seed use ranged from 88 percent in Brazil to over 90 percent in Bolivia, Paraguay, Uruguay, and Argentina. The goal of their adoption was to simplify production practices by reducing applications of agrochemicals and increasing productivity (ibid., 255).

Initially, Japanese oversea farmers brought soybean crops to South America for agronomic experimental purposes only. In the 1960s and 1970s, Japanese farmers arrived and were connected to market production, although they never reached the size of large-scale farms. Brazil and Argentina served as "incubators" for new transgenic crop varieties, while Paraguay, Uruguay, and Bolivia received the technologies and crops once they were refined and perfected (Oliveira and Hecht 2016, 253). Bolivia's soy production reached a profitable level and became widely-spread and highly mechanized in the 1990s and 2000s. Especially "tropical soy," a GM plant that can "grow in more acidic, low-phosphorus soil conditions than temperate areas of China" enhanced South America's soy production (ibid.). Bolivia adopted GM soybean seeds in 2005. On the one hand, its small farmers profited from it, but on the other hand, it also increased their dependency on external inputs, such as pesticides, fertilizers, and GM seeds (McKay and Colque 2015, 586).

In Brazil, soybean played an essential role in immigrant subsistence crops. It first supported the emigration of poor Japanese farmers only but soon became "instrumental to the global explosion of soybean production." Since 1908, Japanese immigrants started cultivating soybeans for their own consumption in southeastern Brazil and, thus, literally planted the seeds for South America's transition towards their green revolution, including a technical transformation of grain production. Soybean production spread quickly in Brazil and brought pacification between immigrants and natives along with the integration of Brazil's hinterlands. This expansion of soybean agribusiness is partially owed to Japanese funding (Oliveira 2016, 350), which reflects Japan's need for sufficient grain on the international market. This interest met Brazil's goal to expand agribusiness in the central highlands, where most soybeans are being produced. The Japanese International Cooperation Agency (JICA) offered not only credit but also technical support for the advancement of soybean production technology to Brazil (Oliveira 2016, 356).

Brazilian and Japanese interests not only met each other's needs in grain demand but even reached common geopolitical interests of sidestepping American corporate and state control through new trade as an important factor (ibid., 537). To reach this goal, one of the measures was Japan's collaboration with Brazil and Mozambique through a three-way cooperation agreement, which expanded Japan's influence from South America to Africa. This trilateral collaboration assembles "Japanese capital, Brazilian agro-industrial technology, and Mozambican land and labor." This project united the interests of all three nations, including Japan's needs as a net grain-importing country (Oliveira 2016, 359). With the application of GM technology, Brazil rose to the second-largest soybean exporter globally (Kou et al. 2015, 2163).

4.1.3.3. Intermediate results of peer country influence in China and Japan

China and Japan are both subject to peer country influence as well as sources of influence on other countries. Since both East Asian countries are among the more experienced adopters in the biotechnology sector, only very few countries were more advanced to have the capacity in successfully exerting peer country influence on China and Japan. One example would be the US, as one of the few senior adopters preceding China and Japan in GM crop development and adoption. However, in terms of regulations, both China and Japan followed the EU's precautionary principle, especially for the labeling and approval process (Wang et al. 2004, 69; Nishizawa and Renn 2006, 52). The role of peer country influence can be attributed to Japan based on the crucial role it actively played in South America in the introduction and development of soybean production (Oliveira 2016, 356), which inevitably led to the adoption of GM technology. While falling short of causing a "domino-effect," China's adoption of GM crops instead provided a reason for developing countries to consider GM agri-biotech as an alternative production method to meet and profit from the new Chinese market that emerged with a growing food demand (Leguizamón 2014, 157).

4.1.4. Technical capacity of China and Japan

4.1.4.1. Technical capacity of China

The early improvement of crops through plant breeding was especially pursued by emerging economies, such as China, which recognized the importance of technology's required level and encouraged its development (Louwaars 2011, 9). In order to ensure food security and achieve a reliable supply of agricultural products, China started to encourage and benefit from the innovation of plant biotechnology since the mid-1990s already, especially in the face of its potentials in regards to sustainable and efficient crop production. In this context, the seed sector's development remains a key factor that is recognized in China (Xu et al. 2017, 97). Like many countries, China hoped to achieve modern farming through seed research and production. The focus was usually directed on the improvement of crop varieties that were crucial for national food security (Louwaars 2011, 10). In the past years, the Chinese government invested in R&D institutes and domestic companies with the task of developing home-grown biotech-seeds. Along with these investments, discussions are expecting an acceleration of approvals for pending GM crops for cultivation (Xu et al. 2017, 97). Advancement in field management, such as "high-density planting, controlled-release fertilizer, and biocontrol of disease and pests" is being pursued through biotechnology advancement and adopted for seed crops and their processing. Furthermore, China is also using drones as precision tools for more developed supervision (Hu et al. 2017, 127).

To establish the beforementioned technical tools, China adopted several initiatives in the form of national plans to reach sustainable crop production and the required technical capacity. The 12th Five-Year Plan in 2011 is the most prominent one and addressed both the MOST and the MOA, particularly in terms of agri-biotech. The MOST was specifically tasked with forwarding "indigenous innovation" with emphasis on the importance of biotechnology and national food-security strategies (Gilmour et al. 2015, 77). This ministry was responsible for the development of biotechnology by supporting basic research, key technologies, and expanding innovative capacity of biotechnology sector. The 12th Five-Year Plan also addressed the MOA regarding agricultural S&T development and charged it with transforming scientific R&D into industry capacity among managing agriculture and its innovation. The advancement of S&T in the seed sector was included in this plan as well, which should lead to the discovery of genes that would enable the development of new crop varieties "with high yields, multiple-resistance, and wide adaptability" (ibid., 78).

The breeding of hybrid rice is one of China's significant global contributions, occupying over half of the Chinese rice land. Hybrid rice is one of China's technical innovation results and recognized as a crucial factor for the improved utilization of limited agricultural resources. China's advancement in key industry technologies is also reflected in the application of modern agricultural methods, such as "rice straw mulching technology," to reduce water and soil loss on sloping croplands by 70 percent and managed to raise soil productivity by 20 percent. (Xu et al. 2017, 97).

China has upgraded its food legume production in recent years, which reflects its advancement in the seed sector since the very seeds of legume crops are the needed products that can be further processed into food and oil or feed. Due to China's extensive territory, there is a wide variety of cultivated legume crops, including "pea, faba bean, common bean, mung bean, adzuki bean, and cowpea." Food legumes remain an important group of food crop considering their role in the Chinese diet for traditional dishes and their nutritional value. Since China is favored with a large territory of different ecosystems, it benefits from the ideal environment for a wide range of different legume crops (Li et al. 2016, 115)

A similar trend can be detected in China's approach towards rapeseed, which is the country's largest oilseed crop, covering about 20 percent of the world production in 2017. China is one of the leading nations in rapeseed research and has sequenced whole genomes of rapeseed through which important agronomic traits were identified, such as "yield, seed oil content, fertility regulation, disease and insect resistance, abiotic stress, nutrition use efficiency" among others (Hu et al. 2017, 127). These identifications enabled the adoption of advanced breeding and production technologies that can enhance specific traits. Through the research of crop breeding and seed development, China attempts to increase the quality and varieties of seeds and crops, that would include more desirable traits, such as enhanced oil yield, early maturation, higher yield and more resistance to organic and non-organic stresses (Xu et al. 2017, 98).

Policy support is the fundament for the promotion of new technology. China started the groundwork for its agri-biotech regulations in the 1980s and developed biotechnology policies throughout the 1990s. In 1982, China first started publicly to support agri-biotech-related studies. The MOST issued a document involving biosafety issues, such as safety assessment, approval procedure, the application of biotechnology, and legal concerns. This document later became the framework for the development of agri-biotech and GM policies, which the MOA used in 1996 for safety control measures of agricultural genetic engineering. The early 2000s was crucial for the country's GM biotechnology's development since most of its key regulations were developed during that time for the application of biotechnology, including trade and labeling regulations (Gilmour et al. 2015, 74).

The State Council amended the MOA's document from 1996 and released a more comprehensive version in 2001, which became the fundament for biotechnology's governance with the focus on "research and testing, production and processing, marketing, and supervision and inspection." Based on the State Council and MOA's documents followed a series of amendments in the years after, such as improvements for labeling, and allocation of food hygiene to the Ministry of Health (MOH). GM biotechnology's current regulations are governed by the State Council's 2001 regulation and three decrees from the MOA, one decree from the MOH, and the AQSIQ each. Together the State Council, the MOA, the MOH, and the AQSIQ oversee the development of agri-biotech in China (ibid.).

As common for public institutions, these are usually well-staffed in China's biotechnology sector as well (Xu et al. 2017, 97). R&D personnel in 2012 was 4.62 million persons and increased to 6.21 million persons in 2017 (NBSC 2018b). China remained in 2019 the country with the largest R&D personnel for six years (Xinhua 2019b). While, according to Deng et al., most managers from feed and chemical industries in China did not have a degree in biology or other related fields and therefore had only limited expertise on biotechnology, the managers from the seed sector represented the exception to this rule. From a list of 70 seed firms provided by the MOA, 68 percent of the managing positions were occupied by employers with a biology major or a major in related fields and equipped with biotechnology knowledge (2017, 389). China started publicly supporting agri-biotech R&D in the early 1980s and employed 30 000 scientists in 200 publicly funded biotechnology labs by 2015 (Gilmour et al. 2015, 74).

China's National Biosafety Committee of Agricultural GMOs was founded in 2012 and tasked with the science-based safety assessment of agricultural GMOs. The Chinese NBC and the MOA work closely with each other, since the MOA is responsible for examining and approving the safety assessments, which the NBC performs for the MOA (Fu 2018). NBC members are picked based on recommendations submitted at the inter-ministerial joint meetings involving twelve different departments that offer candidates from a wide range of diverse professional backgrounds. However, based on previously assembled committees, the lion share of chosen members seems to be concentrated in the fields of agriculture and environment, followed by food safety and quality inspection. It is worth mentioning that these joint meetings are led by the MOA and focus on the safety management of agricultural GMOs. The NBC in 2012 encompassed 64 members with most experts from the fields of agriculture, environment, and food safety. The invitation for the candidates, which generally involves a term of three years, will then be issued by the MOA (Kou et al. 2015, 2160).

Next to the NBC, China founded the "National Standardization Technical Committee for Safety Management of Agricultural Genetically Modified Organisms" or the "Standardization Committee," a technical organization subject to the MOA. It is in charge of R&D, as well as reviewing technical standards of safety management. The Standardization Committee consisted of 41 members and released 132 national standards for GMO trials. China has also established additional testing institutions for environmental and food safety of GMOs. A total of 40 testing institutions are certified by national standards and approved by the MOA through passing its examination. Therefore, they are qualified to conduct a variety of tests that are required to determine environmental and food safety of the GMOs in question and function as technical support for the Safety Committee and other relevant departments with supervising functions of GMOs by offering findings of their safety evaluations (Kou et al. 2015, 2160).

Public support for the agri-biotech sector started in China in 1982. An increase of agri-biotech application occurred in the early 2000s, which China encouraged through its biotechnology-friendly regulations by promoting the R&D and application of this technology (Louwaars 2011, 10). Unlike some countries, where several ministries are divided by disagreement especially in the issue of finding a balance between promoting biotechnology and preventing its risks, in China the MOST has primary responsibility for the promotion of biotechnology and assisting public-private commercial companies (Newell 2008, 125). In order to financially support the advancement of biotechnology, China formed in the 1990s several fund strategies through several ministries next to the existing national plans and programs. One example would be the special program set up by the former State Commission to promote the commercialization of high-technologies, which encompasses biotechnology as well. The MOST contributes to financial investments for biotechnology development through funding projects that generate revenues for R&D of biotechnology (Gilmour et al. 2015, 75).

Subsidies for grain, seeds, and agricultural machinery were introduced not only to ease the adoption of new technology but also stimulate farmers to pursue their profession with increased creativity and enthusiasm. Under the “Household Responsibility System” in 1978, every household was allocated with a specific land area for farming. Under this system, farmers were encouraged to use chemical fertilizers and extend their working hours, which both led to an increase in grain production. Another agricultural policy milestone appeared in 2004 when the government decided to remove a long-term policy involving farm households’ taxing. Along with this measure, a series of subsidy payments for farmers were introduced to enhance grain production, including subsidies for grain, input, quality seeds, and agricultural machinery. With the support that came along the beforementioned policies, adoption of novel agri-biotech and improvements in grain productivity occurred throughout China’s past decade. Therefore, providing incentives for farmers for efficient grain production remains an integral part of agri-biotech promotion (Jiao et al. 2018, 758).

Some of China’s most fundamental programs and public investments in R&D of biotechnology were its “863 Program,” “973 Program” and several of its most recent Five-Year Plans between

2006-2011 (Gilmour et al. 2015, 74). The 863 Program, also "State High-Tech Research and Development Program," was a national program for R&D of high-tech managed by the MOST since 1986 and adopted by three successive Five-Year Plans. It allocated biotechnology the largest sum of the funds and prioritized "bioengineering, gene manipulation, bioinformatics, and bio-agriculture." In terms of R&D of biotechnology, the budget and funds in the 1990s were initially invested in its regulations that encouraged biotechnology's advancement (ibid., 75). The 863 Program was the first national program to encourage thousands of scientists to focus on biotechnology (MOST n.d.a.). The 973 Program followed in 1997 when China rediscovered the importance of basic research and was also known under the name of "National Program on Key Basic Research Projects." Chinese scientists were being mobilized to conduct innovative research in the fields of "agriculture, energy, information, resources and environment, population and health, materials, and related areas" (ibid. n.d.b.). Here, biotechnology was reconfirmed again as one of the S&T development goals until the mid 21st century (Huang and Wang 2002, 124).

The Five-Year Plans between 2001 and 2015 all included measures for the advancement of biotechnology. The 10th Five-Year Plan tripled China's public funds for life science and biotechnology from 238 million dollars to 795 million dollars, which led to an increase in R&D of agri-biotech crops, such as GM crops like Bt cotton. Until 1999, China still spent less than 1 million RMB (Renminbi) on agri-biotech. However, in 2002, this number rose to 7 million RMB annually and doubled to 14 million RMB by 2003. During the successive plan, China rose to one of the top global players in the biotechnology sector. The 11th Five-Year Plan for the years of 2006-2010 continued offering public funds and investments worth 50 billion RMB with the focus on "GM seeds, biotech-based manufacturing, bio-energy, and biotech-based environmental protection" (Gilmour et al. 2015, 76).

The 12th Five-Year Plan for 2011-2015 identified biotechnology again as one of the key elements for development and prioritized bio-agriculture next to bio-pharmacy, -manufacturing and -energy. The public investment rose during this period to 2 trillion RMB. In the 13th Five-Year Plan for 2016-2020 China still considered biotechnology as a strategic development priority; however, it shifted more resources to biotechnology's use in the health care sector to upgrade biopharmaceuticals considering its vast aging population. The R&D of GMOs was still being encouraged and even removed from the "prohibited" category of foreign investment, thus enabling domestic businesses to collaborate with leading international technology companies

(KPMG 2016, 15). China's financial spending on R&D increased in recent years to 2.18 percent of its GDP last year in 2018 and ranked China in the second position globally. The ratio of R&D expenditure to GDP in 2013 amounted to 1.99 percent and rose continuously in the successive years (NBSC 2018a). This means that China spent over 1.96 trillion RMB, which was around 293 billion dollars, on R&D in 2018, resulting in a rise of 11.6 percent compared with the previous year (Xinhua 2019a). Table 6 below shows the numbers of China's financial and human resources summarized from 1995 to 2017.

Year	GERD (current PPP$)[1]	R&D expenditure (% of GDP)[2]	FTE of R&D personnel[3]	Total R&D personnel (HC)[4]
1996	14 200 681.34	0.563	804 000	2 903 000
1998	19 752 480.39	0.647	755 200	2 814 000
2000	33 080 389.50	0.893	922 131	3 223 000
2002	48 106 715.80	1.058	1 035 197	3 222 000
2004	70 156 502.75	1.215	1 152 617	3 481 417
2006	105 564 475.49	1,369	1 502 472	4 132 000
2008	146 113 993.72	1,445	1 965 357	4 967 000
2010	213 485 641.53	1,710	2 553 829	3 542 244
2012	292 196 334.08	1.906	3 246 840	4 617 120
2014	370 605 486.05	2.021	3 710 580	5 351 472
2016	451 411 916.26	2,108	3 878 057	5 830 741
2017	495 980 942.84	2,130	4 033 597	6 213 627

Table 6: China's R&D human resources and financial investments in the years of 1986 – 2017 based on NBSC and the World Bank

4.1.4.2. Technical capacity of Japan

Until the 1990s, R&D in agri-biotech used to thrive in Japan. However, this trajectory detoured in the face of economic instability and public resistance, which caused most private companies to stop their future endeavors in this industry. The public sector assigned what was left of the R&D to government research institutes and universities. In recent years, more innovative methods in agri-biotech, among others also gene-editing methods, received increased attention

[1] Collected from the UIS (2019c)
[2] Collected from the World Bank (2019a)
[3] Collected from the UIS (2019b)
[4] Collected from NBSC (1999) for 1996-1998, NBSC (2002) for 1998-2000, NBSC (2007) for 2002-2006, NBSC (2009) for 2008 and from the World Bank (2019b) for 2010-2017

(Sato 2016). Many high-yielding rice crop varieties in Japan ended up being used as feed crops since these were especially suitable for staple food due to their productivity. The MAFF had been aiming to increase the production of food crops and feed rice by investing into the development of high-yielding seed varieties and decreasing production costs. In order to achieve these targets, biotechnology was identified as a cost-saving production technology with the potential to provide a stable supply. One of Japan's long-term goals was to achieve a stable supply of seed rice with the help of enhanced traits of modified seeds. Next to the technological advancement, the MAFF also announced the importance of establishing and improving "producer-user relations on a long-term basis" in order to enable the beforementioned stable supply and the seed sector to function overall efficiently (MAFF 2008).

The MAFF set the seed sector's development as one of its priorities in terms of solutions for stable food supply. It developed models for the large-scale greenhouse to cultivate food plants with high-density production. Its seed supply center includes a "total artificial light-type plant growing facility," which reflects advanced technical capacity. This is part of Japan's plans for "the Realization of Smart Agriculture," which involves technologies for the improvement of soil productivity, plant seeds, and harvest, among others. In order to upgrade agriculture into a "progressive industry," the MAFF identified technological innovation in this sector as one of the most promising solutions with the potential to reach rural areas. Information communication technology was also one of the priorities that should connect the rural areas and enable easier information access for farmers (MAFF 2015, 21). Already in 1989, Japan and the US initiated a joint project for the R&D of new varieties of seeds. One of the reasons for Japan's advancement in the seed sector and the biotech-sector, was the supportive domestic atmosphere these sectors received within the Japanese society until the early 1990s. The use of GM seeds provided farmers with the advantages of saving physical labor and cutting down their expenses. Despite the GM seeds' higher retail prices, their overall prices remained lower than those of non-GM seeds (Yamaguchi and Suda 2010, 391).

In the past years, Japan grew increasingly reliant on not only GM grain but also oilseeds (Sato 2016), which also largely requires GM technology for the development of rapeseed and soybean oils (Ma et al. 2017, 458). Oilseed rape is a crop that is being imported for the production of plant oil through its seeds, for which Japan has acquired the technology for further processing and distribution. Most of the imported oilseed rape are GM crops with the trait of herbicide tolerance. Despite not cultivating any food crops for commercial purposes, Japan holds the technical capacity for processing oilseed rape and tracking down accidental loss and spillage of imported GM crops around major ports and along the roads that lead to the important facilities located further inland (Devos et al. 2012, 8). Japan's technical capacity for using GM crops is also reflected in its ability to handle and use these food products safely, which increases consumers' acceptance and confidence towards food products containing GM crops, especially when appropriate scientific information is conveyed (Sato 2016).

Science, technology, and innovation are considered in Japan as essential drivers for its economy and crucial in achieving sustainable growth. Innovations are led by the Council for Science, Technology and Innovation (CSTI), which operates under the Prime Minister of Japan and in accordance with the MOST's policies. It promotes the planning and coordination of science, technology and innovation policies and is also responsible for the formulation and allocation of their budgets (Cabinet Office, GOJ 2017a, 4). In terms of innovation in agricultural S&T, Japan has a case-by-case approach towards products resulting from innovative technologies, including GM crops (Ishii and Araki 2017, 46). Therefore, Japanese researchers tend to apply a rather conservative and cautious approach towards R&D, especially for new technology (Sato 2018).

Japan has an existing national food committee, known under the Food Safety Commission of Japan (FSCJ), and is an independent body under the Cabinet Office created in 2003. Its main staff members include four full-time commissioners. The role of the FSCJ involves conducting risk assessments for food safety purposes for the MHLW and is not to be confused with the role of risk management institutions, such as ministries like the MAFF, MHLW, or the MOE. The FSCJ shows transparency by allowing the public access to its weekly commission meetings. The FSCJ functions as an intermediate between the Scientific Panels and the beforementioned risk managers. It accepts draft reports from the Scientific Panels and submits these upon discussion to the respective risk managers (FSCJ 2015, 2). The Secretariat represents a supportive role in risk assessment for the FSCJ and encompasses "60 officials, 30 technical advisers, and 20 assistants." It is primarily involved with the organization and communication of findings and scientific works conducted by the "Commission and Expert Committees" (FSCJ 2015, 3).

Scientific Panels and "Expert Committee on Planning" respond to the FSCJ and their competent ministries. While the Scientific Panels conduct the necessary risk assessments and consist of more than 200 experts, the Expert Committee on Planning, also known as an "Advisory Committee," is responsible for developing strategic plans for risk assessment and risk communication. The FSCJ and the Advisory Committee of GM Foods both follow national guidelines in line with the Codex Alimentarius for the safety assessment of GM foods (FSCJ 2015, 3). The Scientific Panels are composed of "researchers, academics and representatives from public research institutions," who conduct tests for different food products and additives, including GM foods. Once these Scientific Panels make up their decision, the outcome will be forwarded to the advisory committees to be reviewed. The advisory committee is composed of technical experts and leaders, who forward their findings and recommendations to each of their competent ministries. The final decision lies with the minister of each responsible ministry. For the assessment of GM plants for food, there is a "GM Foods Expert Committee" inside the FSCJ consisting of scientists from universities and public research facilities and designed to conduct scientific reviews for the GM plants submitted to the MHLW (Sato 2018).

In terms of financial investments, political discussions of GM biotechnology in Japan started in the 1970s already. Japan supported its R&D of biotechnology, especially GM technology, by formulating the regulations by the end of the 1970s and enabling the technology's adoption by the 1980s with application in medicine, industry, and agriculture (Shineha and Kato 2009, 142). By the end of the 1980s, Japan started to work with the US on joint projects in biotechnology (Yamaguchi and Suda 2010, 391). The GOJ started investing more broadly in S&T by the end of the 20th century going beyond the technology-driven economic growth it pursued the decades before when major investments were made in computing and automobile sector. These governmental measures are stated in Japan's "Science and Technology Basic Plan" (Basic Plan), which is drawn up in accordance with the "Science and Technology Basic Law" on five-year basis. Its formulation involves two steps. In the first step, the CSTP conducts a policy about S&T, which, in a second step, the government formulates and announces as the beforementioned Basic Plan (Cabinet Office, GOJ n.d.b.).

The First Basic Plan for the years of 1995-2000 reflected Japan's "technology-first approach" with a strategy covering a broader field of interests following the international hype for biotechnology, nanotechnology, and health technology (Holroyd 2014, 7). Investments were especially made in university education and basic scientific research to solve problems in environment, food and energy (Cabinet Office, GOJ 2006, 8). It also initiated a program to raise 10 000 postdoctoral positions to foster the next generation of young researchers (Cabinet Office, GOJ 2006, 18). The First Basic Plan recommended doubling past R&D investment in order to reach the same level of major western nations in terms of GDP by the 21st century. Therefore, a raise of the total budget for S&T of 17 trillion yen by the year 2000 was aimed for (Cabinet Office, GOJ 1996, 15). Despite severe financial conditions, Japan still promoted intensively R&D and basic research (Cabinet Office, GOJ 2006, 3).

Biotechnology was explicitly mentioned in the Second Basic Plan for 2001-2005, with GMOs being identified as part of the prioritized areas in Japan's promotion strategy in 2001, especially in their use for medicine and food production (CSTP 2001; Cabinet Office, GOJ 2001). Even though the "10 000 researchers-support-plan" from the previous plan was realized by this time, complications arose out of this measure, such as graduates' difficulties in finding jobs (Cabinet Office, GOJ 2001, 16). To continue the promotion of S&T, Japan aimed in its Second Basic Plan to not only maintain the achieved level of R&D expenditure as a percentage of GDP, which was 2.906 percent at that time, but also to draw level with leading Western nations and surpass the 3 percent mark (ibid., 19). However, by this time, Japan's fiscal conditions deteriorated again and the government expenditure for R&D did not reach the planned 24 trillion yen. In terms of biotechnology, the Second Basic Plan mentioned its use to secure stable food supplies of high quality (ibid., 11). Here, Japan officially identified biotechnology's potential to contribute to food security next to a healthy diet and sustainability in food production (ibid., 23).

The Third Basic Plan reflected rising civic concerns in GM biotechnology by listing GM foods under bioethical and social issues, addressing it along with anxiety and concerns that stirred in society in the early 2000s. While social trust became an important goal to be achieved, R&D are still being encouraged, however, in compliance with stricter rules in terms of bioethical issues to mitigate civic concerns. The governmental R&D expenditure for the years of 2006 to 2010 was estimated at 25 trillion yen, with the same goal to finally catch up with the US and major European countries (Cabinet Office, GOJ 2006, 3). Main resources were allocated to the prioritized areas of "life sciences, information and telecommunications, environmental sciences, and nanotechnology/materials" (ibid., 4).

The Fourth Basic Plan listed GM technology again among the solutions to achieve a stable food supply, including improving food self-sufficiency and enhancing food safety. In this plan, the government announced its goal to promote R&D for the "production, distribution and consumption of safe and quality food material and products” with GMOs to play an essential role. R&D was to be carried out in cooperation with “universities, public research organizations, and industrial sectors” (CSTP 2010, 18). Financially, the Fourth Basic Plan foresaw an expenditure of 25 trillion yen to achieve its set goals, which was the same amount targeted but not reached in the previous plan (ibid., 42). Despite rising social security cost and sobering tax revenues caused by low birthrate and aging population, the target of 3 percent of GDP was achieved during the Fourth Basic Plan (Cabinet Office, GOJ 2016, 69). GMOs were again mentioned under “ethical / legal / social issues.” The development of GMOs was strongly connected with social impact and risk assessments, which the government attempted to address in this plan (CSTP 2010, 36).

By the latest Fifth Basic Plan, biotechnology remained a key sector in achieving stable food supply, especially in the face of potential food shortages and increasing global environmental challenges. However, GM technology’s promotion was not specifically mentioned, unlike in the Fourth Basic Plan. Food self-sufficiency and sustainable growth were pursued with the promotion of “smarter” agriculture through advanced technologies, such as new plant breeding techniques (Cabinet Office, GOJ 2016, 21). The total government investment forecasted for the term of this plan until 2020 amounted to 26 trillion yen based on the target of 4 percent of GDP (ibid., 69).

Japan’s basic plans always aimed for a raise of investment for the S&T sector with ambitious goals to meet Western countries’ research level and expenditures. However, those set goals for investment have not always been able to be implemented. Nevertheless, Japan has been able to increase its investment in R&D of S&T steadily. Table 7 below summarizes the country’s financial and human resources invested in R&D from 1995 to 2017. Japan’s number of persons employed in R&D of S&T showed a continuous growth since 1985 when the number was only at 762 821 persons, including researchers, assistant research workers, and technicians. Within a decade, it increased to 992 465 persons in 1995 and by 2000 it reached over one million persons. The only anomalies in this upward trajectory occurred in 2002 and between 2010 and 2012 when the number dropped to 1.03 million persons in 2002 and again in 2012 to 1.13 million persons (Statistics Bureau, MIC, 2011; World Bank 2019b). The last registered peak occurred in 2017 with 1.20 million persons in R&D (World Bank 2019b).

A similar pattern of growth can be observed with financial expenditures, with an exception in 2010 when the nation's investments for R&D just recovered from a drop from 148.72 million PPP$ in 2008 to 140,62 million PPP$ in 2010, and started its ascending course again to reach 152.33 million PPP$ in 2012. The number of R&D personnel corresponds overall with the trajectory of the R&D expenditures. However, exceptions can be detected in which allocations of financial and human resources diverge in their developments. For example, between 2000 and 2002, the R&D personnel headcount in R&D dropped, while R&D's expenditure kept growing (Statistics Bureau, MIC, 2011).

Year	GERD (current PPP$)[5]	Proportion of R&D expenses to GDP (%)[6]	FTE of R&D personnel[7]	Total R&D personnel (HC)[8]
1995	n.a.	n.a.	n.a.	992 465
1996	82 967 653.90	2.692	891 783	n.a.
1998	90 997 962.42	2.874	925 569	n.a.
2000	98 918 928.85	2.906	896 847	1 045 007
2002	108 166 224.95	3.014	859 453	1 032 826
2004	117 516 713.10	3.030	872 752	1 096 078
2006	138 738 072.95	3.278	910 375	1 148 836
2008	148 719 234.39	3.337	882 739	1 159 722
2010	140 619 125.79	3.137	877.928	1 159 546
2012	152 325 567.88	3.209	851 132	1 132 376
2014	164 655 763.82	3.400	895 285	1 189 017
2016	168 644 912.97	3.141	872 340	1 199 237
2017	175 836 354.38	n.a.	890 749	n.a.

Table 7: Japan's R&D human resources and financial investments in the years of 1995 – 2017

Currently, the Japanese government has been actively promoting R&D of agricultural technologies with the program "Cross-ministerial Strategic Innovation Promotion Program (SIP)," which is a national project initiated by the GOJ to support S&T and induce innovative approaches. It is implemented by the beforementioned Council for Science, Technology and Innovation. In the SIP the GOJ has listed ten sectors that are crucial to revitalize the Japanese economy (Cabinet Office, GOJ 2017b). Agriculture is one of them and represented under the

[5] Collected from the UIS (2019c)
[6] Collected from the World Bank (2019a)
[7] Collected from the UIS (2019b)
[8] Collected from the Statistics Bureau, MIC (2013) for 1995-2000 and the World Bank (2019b) for 2002-2017

program name “Technologies for Creating Next-Generation Agriculture, Forestry and Fisheries” or “Next Generation Agriculture” (ibid., 47). This program, which also supports innovative technologies for agriculture, such as biotechnology, received 3.32 billion yen of the total budget of 50 billion yen for the whole SIP in 2015. In the following year, the program received 2.66 billion yen out of 32.5 billion yen of the total SIP budget. Especially plant breeding with gene modification technologies is being promoted. For the R&D of biotechnology the GOJ has encouraged researchers from public institutes and universities to devote themselves to innovative plant breeding technologies, including GM biotechnology, to develop crops with enhanced traits. On account of these annual public funds, the R&D of crops could be partially or even fully covered with the beforementioned budget provided by the SIP. Results have been published in journals, although no research accomplishment has yet achieved the clearance for commercial release (Sato 2016).

4.1.4.3. Intermediate results of technical capacity in China and Japan

Both China and Japan applied initiatives for the advancement in key industries that were important for the progress in agri-biotech, although each country’s focus varied with the exception of the seed sector, which both countries continued fostering. While China’s research in recent years involved developing specific food crops and field management (Louwaars 2011, 10), Japan seemed to be willing to invest more resources in the development of gene-editing tools within agri-biotech (Sato 2016). Each country has a functioning NBC in place and supporting technical entities, such as technical committees and scientific panels. The difference lies in the scope of available technical staff, in which China dominates in numbers in the R&D sector, but Japan still manages to keep up for a long time with its R&D output reflected by the high FTE number with only a fraction of China’s number of staff available. Financially, both countries are increasing their investments in R&D continuously. While China prevails in the amount being spent in R&D, increasing it drastically on an annual basis, Japan remains clearly in the lead when comparing the spending as a percentage of GDP.

4.1.5. Food security crises in China and Japan

4.1.5.1. Food security crises in China

China put extensive effort to not find itself again in the situation of food security crisis and is currently not ranked in the IPC analysis for any food insecurity (IPC 2020). However, a "looming food crisis" remains a relevant issue due to the domestic challenges the nation is constantly confronted with caused by its large population and limited resources (Liao 2010, 106). Despite low water availability of only one-fourth of the global average and limited arable land of only 8 percent of the global total, which amounts to less than half of the world's average, China has been providing food for 20 percent of the world's population in 2015 (Huang and Yang 2017, 119; Kou et al. 2015, 2163). Several researchers agree that China is still confronted with food security concerns in the long run due to intensified previous challenges and the emergence of new challenges (Liao 2010; Fan et al. 2012; Kou et al. 2015). These concerns can be sources of food security crises if they are not addressed appropriately in time and are therefore targeted by China's agricultural and food policy (Huang and Yang 2017, 119). Since 2013 food security has been listed as one of the country's top major tasks once again (Ku and Yan 2018, 206).

Ku and Yan considered China's unsustainable development as the cause of its past food security crisis. The consequences included overexploitation of agricultural farmland, reduction of farmers, and pollution. Especially industrial waste represented the biggest threat to food safety, due to its easy access to the food chain through irrigation, and reduced grain production as well as self-sufficiency rates (2018, 210). This status was determined based on the example of soybean production. China used to be an exporter of soybean until the mid-1990s but turned into the biggest soy importer by 2000, surpassing even Europe's demand for soy (ibid., 209). Most imported soy originated from the US, Brazil, and Argentina, accounting for 44 percent, 41 percent, and 10 percent in 2012. Most of the imported soybeans were transgenic and the source for food safety concerns within the population, despite the government's support for domestic commercialization (ibid., 208).

Some food security-related challenges were caused by the high cost of food production and lowered international competitiveness in the agricultural market. Even though Chinese farmers' income had been growing, their average remained low. The nation's recent agricultural and food policy focused on reaching “national food security, higher growth of farmers’ income, and sustainable agricultural development” (Huang and Yang 2017, 119). The enhancement of self-sufficiency, especially concerning agricultural goods, remained a primary subject on the national agenda. For this purpose, the domestic adoption of GM food crops represented a method to achieve higher yields (Kou et al. 2015, 2163).

Other challenges closer to Mabaya et al.’s concept of causes for food security crisis (2015, 587), including the beforementioned limited resources of both water and arable land, were becoming more acute with each passing year in China (Liao 2010, 103; Kou et al. 2015, 2163). The most common food security crises were caused by environmental threats, such as droughts and pest outbreaks (Mabaya et al. 2015, 587). When dealing with the beforementioned challenges next to the consequences of climate change and protecting domestic natural resources, agri-biotech was considered as a promising solution. The improvement of agricultural productivity can be achieved through technological innovation, especially when the potential ceiling of conventional cultivation had already been reached (Gao et al. 2018, 136).

In the face of limited water resources, the R&D of crop varieties with enhanced drought-tolerance rose in importance in China. Limited arable land became another crucial challenge for a country with growing food demand. China’s arable land encompassed 118.9 million hectares, and land under permanent crops accounted for 16.0 million hectares in 2017. While China’s land under permanent crops had been continuously growing, its overall arable land showed a steady decline proportional to the previous item (FAO 2019b). China already used almost its entire capacity of available arable land for agriculture. Therefore, the potential to increase arable land was low. Increasing food demand can only be met domestically by raising the amount of food production from the same or less amount of land since arable lands were being lost to excessive use of agricultural chemicals without countermeasures. Even China’s available arable land had poor soil quality, which complicated conventional measures for improving crop yields. For policymakers, it had become clear that the adoption of technological and policy measures was needed in order to raise sustainability in agriculture (Fan et al. 2012, 15).

Degradation of soil is one of the human-caused threats, unlike droughts or pests. Since the 1970s, China increased its crop production by excessive use of agricultural chemicals on crop fields. The increasing amount of used pesticides led many arable lands to lose their soil fertility.

Pesticides have not only harmful consequences for soil but also affect water quality. Therefore, its excessive use has the capacity to reach the entire agricultural ecosystem through soil and water. However, reductions of pesticides can only be initiated if alternative options are at hand. One of these alternatives can be offered by the adoption of crops resistant to major pests, which can be achieved by advancing agri-biotech. Therefore, China followed the US's example and started to increasingly invest in the R&D of GM crops with pest and disease resistance, which makes up 90 percent of China's field trials (Zhang and Zhou 2003).

The improvement of crop yield through plant breeding is critical for future food security, especially in the face of both resource limitations and growing environmental challenges. Yield potential is the yield of a crop grown under ideal circumstances without both limitations on resources as well as the occurrence of pests and diseases. For the average farm yield, 80 percent is considered to be the potential yield ceiling, especially for rice. This means that it is difficult for farmers to achieve higher yield levels through conventional measures, such as "fine-tuning in soil, crop, water, nutrient, and pest management" (ibid.). In this case, the improvement of yield potential that has already reached its conventional maximum can be achieved through genetic enhancement of crop varieties. According to Fan et al., China's R&D should combine both traditional breeding methods as well as advanced breeding technologies, including GM technology, to raise yield potential (Fan et al. 2012, 20).

Genetic engineering is viewed as a possible way to boost China's food security by improving agricultural productivity while decreasing the impact of industrialization and the adverse consequences of agricultural chemicals' excessive use (Zhang and Zhou 2003; Gao et al. 2017, 128). The investment in agri-biotech and adoption of GM crops is also regarded as a strategy to address the beforementioned international competition of the global agricultural market and technology industry. The promotion of R&D in GM biotechnology again has a vital role in achieving national food security due to the edge it can offer in global competition (Kou et al. 2015, 2163). Among a series of strong policy measures, including the elimination of agricultural tax and increasing agricultural subsidies, the raise of agricultural R&D expenditure is also an important policy measure adopted by the Chinese government to ensure food security (Kou et al. 2015, 2163).

The most effective demonstration of benefits brought by the adoption of GM crops would be China's cultivation of Bt cotton. Even though it is not an edible plant, its cultivation shows the benefits that would also be relevant for GM food crops. According to Chen et al., the use of pesticides was reduced immensely through the adoption of GM cotton with resistance towards bollworms. Previous outbreaks of cotton bollworms caused high losses for Chinese farmers. However, due to lack of knowledge and training Chinese farmers were still using too much pesticide in the hope of cutting more losses and raising higher crop yields. Therefore, supporting policies were required to help farmers reach the maximal benefits of new technologies by offering them sufficient information and training to enable their correct applications (2013, 22).

Xie et al. showed the impacts of GM crops adoption based on the advantages of potential GM maize commercialization in China, which reached far beyond the maize sector itself and should act as a countermeasure for rising prices, and limited resources. Commercialization of GM crops would increase not only yield but also save pesticide and labor costs. By increasing output, it can lower the crop's price on the market. The "inherently higher yield" of GM crops would save the land area and open up more space for the production of other crops (Xie et al. 2017, 349). Ideally, the expansion of domestic crop production and crop price reduction would lead to less dependency on food crop import and even increase export. The rest of the agricultural sector is also expected to grow once there is a surplus of available extra crops. Higher supply of agricultural goods can reduce their prices, which again would bring welfare to Chinese consumers. Farm sectors that use maize as feed would belong among the beneficiaries as well. According to the authors' research, the only major loser of GM maize commercialization would be the chemical sector, whose pesticides and similar agricultural chemicals would be vastly replaced by the innate resistance that comes along pest-resistant GM crops. Other predicted benefits that could be brought by GM maize adoption through the reduction of pesticide use would include positive effects for both the environment as well as human and livestock health (ibid., 351).

While advocates for GM crops argue that their adoption would prevent food safety issues caused by the intensive use of pesticides (Xie et al. 2017, 349), this very argument of food safety issues is also used by anti-GMO activists to criticize GM food crops. Anti-GMO activists see the same danger caused by agricultural chemicals in GM crops as well and thus question their safety for consumption and health (ibid., 341). Another challenge concerns the adoption of GM crops by small farmers. According to Liao, "small farm is still the backbone of China's sustainable growth," and more than half of the population resides in rural areas. Each household owns less than 0.5 hectares of land, which is often scattered in numerous separated plots. This kind of ownership decreases the incentive for small farmers to adopt modern agri-biotech (2010, 106). Even after the adoption, farmers often cannot enjoy the maximum benefits due to a lack of training and knowledge about the newly adopted technology. In China, many farmers are unable to acquire updates on relevant information "due to the lack of appropriate extension services" (Jiao et al. 2018, 761). Another concern is the tendency of young farmers leaving the rural area and preferring lives in cities over agricultural work at home (Liao 2010, 106). In 2018, China's rural population encompassed 40.8 percent, while its urban population accounted for 59.2 percent (FAO 2019b).

4.1.5.2. Food security crises in Japan

Even though Japan is also not listed in the IPC analysis for food insecurity (IPC 2020), its food self-sufficiency rate has found itself on a continuous declining trajectory and decreased from 73 percent in 1965 to 39 percent in 2013. Most of the Japanese population's food are imported goods from the US, China, and Thailand (Reiher and Yamaguchi 2017, 3). Reasons for the decline of the Japanese agriculture sector includes both the aging farming population and the decreasing numbers of farmers. In 2018, its rural population encompassed 8.4 percent only and 91.6 percent urban population. Limited resources are another crucial component that can lead to food security concerns. Arable land declined from 5377 thousand hectares in 1967 to 4161 thousand hectares in 2017, and land under permanent crops decreased from 561 thousand hectares in 1967 to almost half its amount of 283 thousand hectares in 2017 (FAO 2019a).

Unfavorable weather conditions also took their toll on domestic yields and can cause sharp cuts to domestic crop outputs. Soybean and cotton were susceptible to droughts, while rice crops suffered the most under frost (ISAAA 2016, 89). This was especially the case in 1993 when a cold summer caused poor rice yields and the shortages that followed, resulting in Japan's first dip below 40 percent self-sufficiency. Until the mid-1960s, Japan still held the level of self-sufficiency at 70 percent through domestic food production. Nevertheless, by 2015 the country became one of the largest importers of agricultural products for food and feed. Therefore, the GM crops import turned out to be inevitable, since three quarters were produced using GM biotechnology, especially in feed and food crops. Japan imported 15 million tons of corn and 3 million tons of soybean. Despite the occasional dipping of domestic rice outputs due to unfavorable weather conditions, Japan's rice self-sufficiency remained 96 percent in 2015.

However, its self-sufficiency for grains overall was only 28 percent in the same year and, thus, showed high dependence on foreign countries in terms of grain supply (Nakai et al. 2015, 930).

The cooperation between government officials and scientists are especially crucial during times of food crises and food scares. Japanese policymakers are especially susceptible to consumer resistance, which admittedly represents a strong force in Japan. However, it becomes even more crucial to disseminate correct information to ensure scientific and technical certainties among all stakeholders during challenging times. With sufficient accurate information, Japanese consumers would learn that zero risks, which are repeatedly demanded from the public as a standard for food safety, is not feasible (Reiher and Yamaguchi 2017, 5). Nevertheless, policymakers generally attempt to concur with consumers' demands in order to win new voters or prevent losing existing ones from one of the biggest interest groups. Especially elected politicians are under strong influence from public opinion (Mabaya et al. 2015, 585).

Japanese farmers seemed not to be as opposed to the idea of GM crop adoption as consumers, especially in the face of decreasing yields when environmental odds were stacked against productivity. On the contrary, farmers from some regions even continuously considered cultivating GM crops only to find their plans regularly intercepted by strong opposition led by citizen groups. During one of the drops of crop yields, Hokkaido farmers chose the cultivation of GM soybean in 2005, which, however, never went through due to massive consumer protests. These farmers had to withdraw their plans when even the local governments turned on them by adopting bans for field-testing of GM crops and complicated regulations in response to consumer concerns (Nishizawa and Renn 2006, 45).

Overregulation is one of the reasons Japanese farmers were prevented from using innovative agricultural technologies that would be beneficial for them. Traits that enhance resistance towards unstable and harsh weather conditions could prevent losses that occurred in previous years. Especially extreme temperatures, such as frost and droughts, can cause extensive damages to agriculture (FAO 2014, 157). Japanese farmers are additionally burdened with extra costs for required tasks, such as documentation and monitoring of their crop production. The cultivation of GM crops was accompanied by more financial risks than benefits. In the case of breaches, there were fines to be paid while trading companies had no obligations to accept farmers' products (Reiher and Yamaguchi 2017, 5). Instead, farmers would have to deal with the stigmatized image of GM products (Nishizawa and Renn 2006, 45).

For a successful submission for an application to the local government, Japanese farmers needed to absolve a series of complicated steps. The resulting expenses during these steps were all to be covered by the applicant. These included Japanese farmers hosting public meetings with their neighboring farmers and documenting all the meetings held for application purposes. Farmers were required to provide their exact methods for coexistence strategies and monitoring the crops. Furthermore, there were also processing fees for each application with no guarantee that additional expenses might occur caused by changes to the application in the future. By 2015 Hokkaido farmers remained secluded from the latest agri-biotech, when another petition with requests for allowing field tests of GM crops went unanswered (Sato 2016).

4.1.5.3. Intermediate results of food security crises in China and Japan

In terms of agriculture, both countries are under pressure caused by environmental challenges, although Japan's situation seems to be direr due to its rapidly decreasing food self-sufficiency. Both nations are struggling with limited arable land, though China is still capable of converting arable land to land under permanent crops and thus increasing the latter. Farmers' and policymakers' perceptions vary depending on the influences from their environment. Once these influences turn into pressure, both groups of stakeholders tend to take the safer road and abandon the GM crop adoption to keep consumers' favor (Reiher and Yamaguchi 2017, 5; Sato 2016). Japanese farmers need to additionally consider the financial risks that come with any application for GM crop cultivation (Sato 2016). Chinese farmers, on the other hand, are supported by their government in terms of adopting new biotechnology to improve productivity (Huang and Yang 2017, 122). In contrast, Japanese farmers have to deal with strong oppositions of unsatisfied consumers on their own (Reiher and Yamaguchi 2017, 5; Sato 2016).

4.1.6. The role of media and activism in China and Japan

4.1.6.1. The role of media and activism in China

Until 2010 Chinese consumers primarily acquired knowledge about GM biotechnology and its products through TV and radio. Based on the surveys conducted by Han et al., these two media tools were considered "the most credible and fair sources of information" by the Chinese population (2015, 4). Compared to other industries, the media industry is one of those under higher regulation and political manipulation, which is a common tendency among developing countries (Chan-Olmsted and Su 2017, 236). All general-interest media in China, including major newspapers and television channels, are under the supervision and ownership of the Chinese Communist Party Committees (CCPC) (Qin et al. 2018, 2443). The structure of media and the surrounding influences can also affect the content it publishes (Mabaya et al. 2015, 385). In China's case, editorial content is under the jurisdiction of the government and public organizations and can only be published by those. Therefore, the Chinese media is state-owned only (Rohrhofer 2014, 172). The Communist Party of China (CPC) has the authority of censorship over all media content and uses it to keep tight control on media (Luo 2015, 54).

The Central Propaganda Department (CPD) represents the party's viewpoint and sets the propaganda rule for Chinese media with priority on national interests over any other topic. Therefore, the CPD is the source of China's "centralized media control." The evidence supporting this theory can, for example, be found in food scandals, such as the milk scandal in 2008, shortly before the Olympic Games. The CPD banned all reports on this topic and allowed releases only after the Olympic Games (Tong 2010, 925). Chinese media has the two concerns of maintaining political alliances with local governments, and the commercial need to make a profit. In these cases, the media tend to lean towards serving political interests. If the media focuses on local interest groups, this shift would cause national and public interests to drop in their priority (ibid., 939). With GM biotechnology and GM crops being increasingly advocated by senior Chinese politicians and acknowledged as a rising national interest, it has started to receive treatment and support from the national media corresponding to its importance to the country (Han et al. 2015, 1).

In terms of GM biotechnology and its products, the Chinese government saw in the role of media not only a tool for propaganda but also a method to increase public acceptance to reach a stable food supply through agri-biotech (ibid.). According to Han et al., the three key stakeholder groups concerning GM foods were the consumers, farmers, and scientists. Consumers and farmers belonged to the primary target groups of the beforementioned educational measures from the Chinese government to pave the way for the successful development of GM crops and their adoption for the domestic market (ibid., 7). It turned out that GM crop farmers, as well as the scientists, shared an overall positive attitude towards GM crops. Chinese Bt cotton farmers were satisfied with the adoption of GM crops due to the economic benefits these enhanced plants had brought to them and shared these experiences with their neighbors and peers. The scientific community was mostly already well-informed about the beforementioned benefits and those beyond economic advantages, such as positive environmental factors. On the other hand, views of Chinese consumers were more heterogeneous and split between those from developed regions with higher acceptance towards GM foods and those from other regions (ibid., 1).

Despite consumer acceptance rising continuously due to public awareness campaigns, it remained one of China's challenges as the nation with the largest plant biotechnology capacity outside North America (Fan et al. 2012, 20). In general, public support needed to be enhanced through active communication between all stakeholders, including government, industry, consumers, and the media (Gao et al. 2017, 136). Unlike scientists, who tended to be informed through their profession, or farmers, who were informed by their peers, Chinese consumers received their knowledge about GM crops and GM foods through various media, "including TV, radio, print media, internet, and others" (Han et al. 2015, 4).

The role of media is, therefore, crucial for consumer groups since they primarily extract information through media, which can either advance or discourage consumer acceptance towards GM crops (ibid.). The relevant Chinese government agencies launched educational efforts with measures to effectively disseminate and convey scientific facts and safety of GM foods through public media to increase consumers' willingness to accept GM crops. Based on both pieces of research conducted by Han et al. from 2007-2008 and in 2010, knowledge of GM foods was primarily achieved through TV and radio, followed by print media and internet. Consumers' trust towards the credibility of the content provided by the beforementioned media categories was ranked highest along with TV and radio as the most credible sources (ibid., 4).

Consumer attitudes were a critical component of a successful GM crop adoption since it had the potential to influence the decisions of government agencies (Han et al. 2015, 1). The attitudes of consumers varied from different types of GM products and can be influenced by the media. Acceptance towards non-edible products of GM crops tended to be higher than edible products of GM crops. The opposition was comparatively higher towards transgenic animal products and GM rice. The majority of Chinese consumers did not seem to be opposed to GM food products. The media played an essential role in the high acceptance of GM foods. According to Han et al., Chinese consumers had high trust in scientists, followed by policymakers and managers in terms of matter in biotechnology. However, the trust for biotech industries was comparatively much lower (ibid., 4). Especially in the past decade, consumer awareness for environmental protection was raised in China. This shift of priority among consumers was also called forth by the media (ibid., 5). Therefore, depending on the media's content, consumers' trust can both be enhanced or discouraged.

Politicians also recognized the crucial role of media in terms of GM foods and GM crops. Jun Han, a Chinese politician and advocate for transgenic technology and consumers' rights, emphasized the recognition of GM technology as a scientific issue, that cannot be comprehended by society, particularly by citizens who were not directly involved with it. Thus, GM technology and its products remained a sensitive topic for the public. For the improvement of this situation, the Chinese government recognized that dissemination of accurate scientific knowledge would be crucial in order to provide the public and the media the necessary information for more understanding about GM technology. In this regard, the media was both a tool to deliver information, as well as a medium that needed to be filled with accurate content beforehand to avoid the spread of biases. Chinese politicians wanted to achieve a more rational view of the population towards GM crops by sharing the high level of their nation's safety management system through the media (Cao 2019, 49).

Despite the ownership and supervision of major media channels, public media is a tool that can be wielded by not only the government but also other stakeholders. In terms of interactions between media and civil society movements, Huang distinguished between "party media, market-oriented mass media, and online alternative media." Party media remains under the government's firm control and is therefore considered "voiceless" during protests. Since party organs have to assure that protests carried patriotic nature, they tend to tailor these movements towards their needs. The "Global Times" is a party organ and promotes the R&D of GM biotechnology. Several party media, such as "Guangming Daily, Jiefang Daily and Zhejiang Daily," accredited GMO controversy to citizens' lack of scientific knowledge (Huang 2018, 148).

Market-oriented media is associated with the market economy, scientific spirit, and liberal civil society and distances itself from becoming "party mouthpieces." Despite speculations that market-oriented media would support pro-GMO stances, the editor of one of its flagships, the "Southern Weekly," stated that the newspaper did not have a standpoint on GMOs. The internet provides citizens with an alternative space for activism despite being under state surveillance (ibid.). Next to civil society, nationalists have also established their platform on online networks to generate social movements. However, the socialist anti-GMO discourse have been marginalized by China's media system in recent years since they deviated from national interest (ibid., 165).

The anti-GMO issue started to diffuse at the turn of the 21st century and spread into a movement that grew and lasted over two decades. The anti-biotech NGOs made use of public media as a platform to broadcast their messages and launch online and offline campaigns led by both international and local groups. Greenpeace played a crucial role by introducing the issue to China since 2001 and remained an active participant. In contrast, the local group named Utopia was engaged with the issue since 2008 with a more ideological focus. Utopia was founded in 2003 by left-leaning scholars, who defended Maoism and attracted many devotees through its left-leaning online community. In 2013 the People's Food Sovereignty Forum, which is an organization consisting of scholars and students from China, joined the Utopia. Even though the beforementioned forum addressed issues related to global food sovereignty, anti-GMO topics were not among their priorities. Greenpeace and Utopia remained the two major anti-GMO organizations on the global and local levels based on their long and active involvement (Huang 2018, 150).

The main causes of the rise of anti-GMO movements in China were the approval of the first biosafety certificates for GM food crops, including GM rice and GM corn, and the "many reports and anti-GM information" released in the public media following these approvals (Han et al. 2015, 8). Especially the Xi regime attempted to dispel public concerns along with its active support for GM biotechnology research. Therefore, China's anti-GMO movement had the commercialization of GM crops as their focus (Huang 2018, 149). Additionally, food safety scandals tend to spread much faster through the media and receive a higher civil response than scientific issues. According to Holtkamp et al., food safety scandals in China were the sources for the public interest in food safety to begin with (2014, 461).

4.1.6.2. The role of media and activism in Japan

The Japanese media plays an important role in the public opinion towards GM biotechnology and GM foods, especially considering Japan being one of the biggest GM product importers

(Umeda 2014). In terms of ownership, Japan's media is a mix of privately and publicly owned (Rohrhofer 2014, 171). The most prominent and influential Japanese media broadcaster is Nippon Hōsō Kyōkai (NHK), which is publicly owned. The main characteristic is the concentration of its ownership, which is divided between five large media conglomerates among privately-owned businesses. Each of them is built on a large daily newspaper, which also owns private broadcasting companies and other printed media, such as magazines and other weekly newspapers (ibid., 172).

The role of media was crucial during the rise of consumer campaigns in 1999, when the lack of labeling was uncovered and remained in the headlines of Japanese media for a long time due to the scandal's popularity. The lack of labeling remained a favorite media story until the government finally announced the introduction of mandatory labeling in the following year (Nishizawa and Renn 2006, 46). In this case, the media assumed an amplifying function for consumers' already negative notions towards GM foods. Following this incident, Japanese mass media focused in 2000 on another food safety scandal known as the "Starlink incident" that involved GM corn imported from the US mixed in Japanese crop shipment. While Starlink GM corns were produced and certified in the US for feed and processed food, it was not in Japan. Matters only turned worse when the responsible MHLW justified the incident in a Japanese popular news program by advocating for the quality and trust of American segregation procedures of GM crops. This statement from a leading ministry on an already sensitive food safety issue combined with the belated preventive measures only reinforced consumers' dissatisfaction and breach of trust towards the government. For the Japanese mass media, the Starlink incident became another food safety scandal that got widely covered and repeatedly reported on (Nishizawa and Renn 2006, 47).

A strong civil society network rose in Japan in the 1990s and reached its peak at the turn of the century (Tiberghien 2006, 29). The difference between Japanese anti-GMO civil society groups and Western civil movements is that the former emerged out of consumer groups, unlike the latter that originated from environmental groups, such as Greenpeace, or farmers' groups. The source of the Japanese anti-GMO campaign was its effective coalitions with related consumer NGOs with large memberships. The prominent leader of the first anti-GMO movement was Amagasaki Keisuke, a former science journalist influenced by European anti-GMO events he attended in the early 1990s. The main targets of his campaigns were food safety, environmental consequences, and multinational corporations (ibid., 30).

Several studies indicated that the majority of Japanese people remained opposed to GM food (Komoto et al. 2016, e23; Nishizawa and Renn 2006, 45; Watanabe et al. 2005, 519). Especially Japanese consumers were among the groups of people whose rejection was most prominent (Nishizawa and Renn 2006, 45). Their two main concerns involved food safety and environmental risks, especially concerning GM food plants' cropping. The fear concentrated on the potential effects of the cultivation of GM crops with food uses and the possibility of comingling with non-GM crops. Scientists and scholars, on the other hand, criticized the beforementioned concerns and cited the lack of basic knowledge as the source of opposition and fear. Many consumers did not have the overall education of their nation's food security status or basic biology knowledge to grasp environmental aspects. Therefore, public awareness campaigns and education were important for the advancement and the domestic use of GM crops (Watanabe et al. 2005, 519).

Beyond food risk perception, Komoto et al. discovered a cultural predisposition that influenced Japanese consumers' acceptance of GM foods. The authors considered consumer uncertainty as a cultural trait in the face of risk and ambiguity. Based on this consideration, the authors stated that "people with low level of tolerance towards ambiguity have high levels of uncertainty avoidance" (2016, e23). This indicated that Japanese consumers preferred clear answers and solutions. Since GM foods' benefits and risks were not clear to many consumers, they tended to opt for resistance out of precaution to avoid potential health hazards that might not have been discovered yet. Japanese consumers, who already showed an overall stronger resistance than many other countries, would require more scientific assurance proofing GM foods' safety. As long as only limited information was available, consumers' attitudes would have to be created based on their own perceptions (ibid.).

Reiher and Yamaguchi counted the struggle between scientists and media as one of the key issues in defining and managing risks, considering the discrepancy between each of their perspectives on GMOs. Their interplay was especially crucial when addressing social controversies about food safety risks concerning GMOs (2017, 5). The authors confirmed the interplay of mass media, consumers, and policymakers, which was predicted by Mabaya et al. (2015, 585) as well, especially when it comes to Japan's food safety risks. Especially popular media was highly responsive to food scares and tend to reflect consumers' discontent or policymakers' attempts of diverting responsibilities. During food scares, the media plays an essential role in managing and communicating food risks. As soon as the public raised concerns, immediate measures were required to be undertaken by the responsible parties, including government officials and scientists, to avoid the spread of food scares through the media to consumers (Reiher and Yamaguchi 2017, 5).

Not only consumers but also Japanese politicians communicate through mass media to convince the population. In terms of food safety issues, the authors listed the “gyōza incident” from 2008, when imported dumplings from China were discovered tainted with pesticides, causing food poisonings. Japanese politicians announced through mass media the danger of all food products from China. This phenomenon is explained by the authors as a behavior of linking certain places with specific risks, even though the risks are present globally. Especially policymakers and food producer companies use this method to avoid their own responsibility (ibid.).

Unlike politicians’ and consumers’ representation in the media, farmers’ needs and perspectives are only sparsely covered. In terms of food safety management, Japanese consumers tend to demand zero risks, which, however, is technically not possible. Nevertheless, policymakers attempted to find a consensus and ended up adopting strict regulations that mostly had to be adhered to by farmers. The responsibility for risk management required farmers to carry out tasks, including documentation and monitoring. These were all costs that needed to be covered by farmers without a guarantee that these financial risks would pay off since retail or trading companies could reject their products if they deemed the quality standards not being sufficiently adhered to (Yamaguchi and Reiher 2017, 5).

Upon the commercialization of GM soybean in Japan, farmers from Hokkaido had the intention to start cultivating biotech food crops for the first time in 2005. However, they had to abort that plan due to strong civic opposition, which again caused the local government to respond to these consumer concerns with rigorous field-testing of GM crops in the region. Other local governments followed that measure to avoid civic unrest and stigmatization (Nishizawa and Renn 2005, 45). GM crops’ cultivation remained unattractive due to the financial risks, and strict government rules Japanese farmers had to follow. Since farmers’ concerns were a less attractive topic than food scares and affected fewer viewers, they remained not much covered by the media (Adenle 2017, 61).

In recent years, the negative media coverage concerning GM foods decreased, and so did the consumer groups' anti-GMO campaigns along with it. There were still campaigns against GM crops in Japan, although the public risk perception had waned. Sato explained this media tendency with the spreading fact about Japan's reliance on imported GM crops, including GM grains and GM oilseeds (2018). Growing consumer acceptance for GM foods was also explained through the population's rising familiarity with GMOs, which was caused by reduced media coverage of GM food scares and consumer campaigns. Both occurred around the same time when the Japanese Consumers' Co-operative Union (JCCU) showed acceptance towards GM foods (ibid. 2016).

The JCCU was the largest consumer organization in Japan in 2016, with 29 million members who used to actively lobby against GMOs with public backlashes and movements against their purchase, like many other Japanese food manufacturers that used to avoid GM ingredients for their products. However, after the peak of grain prices in 2008, some companies started using ingredients that were not segregated (Sato 2016). These non-segregated ingredients encompassed mostly GM ingredients, which were much cheaper due to enhanced plant qualities and easier cultivation. This was especially the case for GM corn, of which 70 percent were imported GM crops and massively used in soft drinks and snacks. Before the prices tripled within two years, Japanese manufacturers used to pay extra for conventionally grown corn to avoid consumer criticism. However, the latest by 2008, this high standard turned out to be too expensive to keep up with (Stone and Glover 2011, 512).

When the JCCU first started using GM ingredients, it still maintained its strong resistance towards biotech-ingredients and emphasized on using them only due to the difficulties of segregation of GM and non-GM products. However, after the price hike, even some of the previous anti-GMO advocates started approaching GM ingredients to cut financial losses (ibid., 2010). In the years following the peak of grain prices, JCCU evolved into a frequent user of GM and non-segregated ingredients in its store brands and labels, even products that do not fall under that regulation. By 2016, the JCCU indicated not only to understand but also to support GM crops, explaining the global adoption of GM crops with the benefits and scientifically proven safety. It endorsed and justified their domestic use by stating that the GM crops that passed Japanese safety reviews had no reason to cause safety concerns. Without the biggest consumer organization's participation in anti-GMO activities, the media lost both support and consumers of the previous headlines with GM food scandals, resulting in a drop of anti-GMO topic's popularity and necessity the years after (Sato 2016).

4.1.6.3. Intermediate results of the role of media and activism in China and Japan

Despite the differences in the structure of the media system in China and Japan and their diverging influences on each population's view of GM biotechnology and GM crops, various stakeholders share some similar tendencies and trajectories concerning their awareness and acceptance of GM crop adoption. China's media is solely publicly owned, and, its content is in accord with the government's policies (Qin et al. 2018, 2443), which has been encouraging the advancement of GM crop adoption (Gilmour et al. 2015, 75). Due to the public educational efforts and dissemination of encouraging coverages about GM crops through the media, China's population has comparatively high acceptance towards GM crops, but is not without consumer challenge either (Han et al. 2015, 3). Japanese media is both privately and publicly owned (Rohrhofer 2014, 172). Therefore, it has more room for civic concerns, food risks debate and food scandals, which tend to be attractive topics, especially among popular media. Japanese consumers are traditionally strong opponents against GM ingredients in their food (Nishizawa and Renn 2005, 45), and build the core of activism (Tiberghien 2006, 30), which is caused as well as reflected by the media.

4.2. Influencing regulatory components during the adoption in China and Japan

4.2.1. Approval process and risk assessment in China and Japan

4.2.1.1. Approval process and risk assessment in China

China initiated the establishment of biosafety regulations only in the early 1990s, while most countries with advanced biotechnology have theirs created and functioning by then already. Nevertheless, despite the delayed start, it currently has a fully functioning and complex approval regulation. There are several stages to pass in order to receive the biosafety approval. First, an official request needs to be submitted to the MOA, which is the main responsible institution for the approval of agri-biotech crop applications, especially for import and domestic productions (Gilmour et al. 2015, 80). The lab tests that need to be conducted thereafter include a number of technical steps themselves again. The National Biosafety Committee reviews the applying GM event before and after the tests. The final stage of the approval process involves the decision to grant or deny the request for the biosafety certification that is necessary for the respective GM events' commercialization (Ma et al. 2017, 461).

In order to gain China's safety certificate and along with it access to its agri-biotech market, the first requirement is a foreign GM event's approval within its own country before China initiates its approval process for the Chinese approval. Approval process generally takes two to three years. The second requirement involves renewals, which are necessary every three years (Ma et al. 2017, 461). Unapproved GM products are strictly forbidden to be neither produced nor traded with. China's commercial approval process is characterized by complexity, which is challenging for potential exporters and investors, especially in the face of the "multi-modal nature of international systems". These circumstances are the perfect incubators for AA situations and, thus, trade disputes (Ma et al. 2017, 461).

In terms of production and trade approval, China applies a zero-tolerance policy concerning unapproved GM crops along with a "time-consuming approval process" (Huang and Yang, 2014, 30; Ma et al. 2017, 460). The zero-tolerance policy refers to the rule that any product containing the slightest trace of unapproved GMOs will be promptly refused. China is also stringent concerning its own approval regulation and requires from all foreign GM varieties to first attain its own native country's approval before China can even consider to accept the submission of a new GM food product and initiate its approval process with tests (Huang and Yang 2014, 37). Once a foreign country finally receives approval, it would still need to look out for the deadline for renewals every three years (Ma et al. 2017, 461). Both of these requirements regarding the length of approval process and renewal can lead to an AA situation (De Faria and Wieck 2016, 87).

Regulations tend to be costlier, the more complex the approval process and compliance procedures are. The effects of these complicated procedures tend to spill over to other sectors, such as trade, which is especially susceptible to complexities in approval procedures (Vigani and Olper 2013, 33). Both the AA situation as well as the zero-tolerance policy are risks for countries that export GM products to China. Such stringent regulations not only result in higher costs but would also render low level presence (LLP) of not approved GMOs into a cause for disruption in trade (Huang and Yang 2014, 31).

A similar divergence between the GM crops using countries can be detected in regards to the earlier mentioned requirement of approval renewals, which is also necessary for China and a prime source for the occurrence of AA situations. The necessity of approval renewal indicates that China issues import certificates for new GM products or GM events with expiry dates. The period of validity varies between each commodity and encompasses an exact duration of time. If approval renewals are not issued in time, then they can become the cause of an AA situation as well. Therefore, import certificates for a GMO event with validity period are necessary to enable trade without disruptions (Ma et al. 2017, 461).

Like other adopters in the initial stage, China is also known to borrow the design of countries with more advanced regulations to adapt the domestic risk assessment process (Newell 2008, 124). A fully developed risk assessment regulation was implemented by the MOA in 2002. The State Council lead JMCs on the safety administration of agricultural GMOs composed of officials from a wide range of different expertise, including "agriculture, science and technology, environment protection, public health, foreign trade and economic cooperation, inspection and quarantine." The purpose of these JMCs is to coordinate safety administration of agricultural GM products. Here the NBC is responsible for conducting the tests for the evaluation and overseeing the inspection and quarantine of new GMOs. The administration of these test results, as well as the safety assessment of the very submitted agricultural GMO fall under the jurisdiction of the MOA or, more specifically the OBA, which is an office established within the MOA for the sole purpose of managing the biosafety of agricultural GMOs (Fu 2018).

Although risk assessment in China seems to be at an advanced stage and labs are equipped with polymerase chain reaction tests, some components indicate inefficiency in regards to the actual commercialization of GM crops. One of them is the complicated inspection and quarantine system used for risk assessment that appear to be designed to dampen imports. Other elements of risk assessment that can influence the commercialization of GM crops are "the variability, high testing sensitivities and the lack of a set threshold for positive results" in the labs for the risk assessment. China's labs for tests of imported products generally have varying sensitivities, which further complicates trade of GM products, where shipments run risks of being completely rejected due to cross-contamination from previously used shipping containers. Even more devastating would be those cases in which a shipment initially was cleared for unapproved events in the exporting country, however upon arrival in China tests positive due to cross-contamination in the shipping container. Complications due to high set sensitivities can also occur at an earlier stage already on the cropland if too much pollen travels from one field to another (Ma et al. 2017, 462).

Based on the beforementioned characteristics of China's approval process, it can be concluded that its main approach follows the precautionary principle, which requires from all GM food products to pass the whole approval process in order to be commercialized. In this process, the State Council has the leading position over fellow central government departments and agencies, such as the involved ministries and committees. It leads the discussions on biosafety and approvals of biotech applications in the JMC (Gilmour et al. 2015, 79). The very existence of the JMC itself would also indicate a precautionary approach, considering it analyzing the risks and benefits of GM food products among a wide range of different stakeholders and represents an additional step between approval and commercialization.

Reasons for this type of approach lie in the nation's biotechnology policies that are utilized to protect local producers and promote domestic biotechnology enterprises. According to Newell, the move towards a more precautionary position is brought about by regulations that are process-based instead of case-by-case and the changes in labeling regulations. One of the main reasons for the revolution of the Chinese labeling regime is the rejection of Chinese soy sauce by the UK due to GM ingredients residues from the US found in these very products.

Assimilation towards international labeling standards turned out to be crucial in order to maintain trade (Newell 2008, 120). China's precautionary stance is also reflected in its reluctance to issue more approvals for the domestic cultivation of further major GM crops since 2005 after Bt cotton was approved (Ma et al. 2017, 462).

China is known for its "contradictory approach towards biotech," including GM products. On the one hand, China is one of the worldwide highest-ranked countries in the field of GM crop research, especially concerning the food commodity of rice. Biotechnology studies are also supported in one of the latest Five-Year Plans. On the other hand, the government seems to be reluctant towards the cultivation of any GM crop, let alone GM rice. Until last year the only approved and commercialized GM crops were cotton and papaya. The regulatory system in China is renowned for its slow and cautious pace concerning approvals of both new domestic GM products as well as foreign GM products for import. Many biotechnology products, which have been submitted years ago, are still in the pending status of their approval process (Ma et al. 2017, 462). Only earlier this year did China's MOA issue biosafety certificates for the cultivation of GM corn and soybean traits and finally took another step on its path towards the commercialization of GM grain production (Gu and Patton 2020).

4.2.1.2. Approval process and risk assessment in Japan

For the commercialization of GM crops in Japan, a three-fold approval is mandatory, including food, feed, and environmental approvals. As mentioned before, there are four ministries involved in the regulatory framework as well, namely the MAFF, the MHLW, the MOE, and the MEXT. There is a customary hierarchy when it comes to the processing of approvals, which admits food the top priority, feed the second and environment the third. This also means that any delays in the higher prioritized categories would also affect the lower-ranked ones. A delay of food approval would cause a delay for feed and environment approval as well (Sato 2016).

GM crops for food are required to achieve food safety approval from the minister of the MHLW. The application process is based on Food Sanitation Law, which was enforced in 2001 and contains safety testing and labeling of GM foods and feeds (Shineha and Kato 2009, 144). The order of application procedure usually starts with an application handed in by an interested party to the MHLW. The minister of the MHLW will then contact the Food Expert Committee for food safety or risk assessment. The Food Expert Committee is the organ that performs the scientific assessment of the food safety review (Sato 2016).

GM products that are used for feed require similar procedures with the difference of needing the consent of the MAFF minister. Depending on the application made by the petitioner, the MAFF might notify the "Expert Panel on Recombinant DNA Organisms" for a review of the particular GM crops for feed use. This panel is affiliated with the MAFF and undertakes the evaluation of feed safety for livestock animals and runs the tests. The results of the tests conducted by the panel would then be evaluated by the "Agricultural Material Committee." A second committee of which the MAFF minister expects an evaluation is the "Genetically Modified Foods Expert Committee", which is part of the FSCJ. This expert committee is responsible for detecting possible effects on human health from the consumption of livestock products originated from animals that were fed with GM crops (Sato 2016).

Environmental approvals are covered by the Cartagena Protocol on Biosafety in Japan. The "Law Concerning the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms" or "Cartagena Law" represents the national implementation of the beforementioned protocol. According to this law, each ministry has different requirements to fulfill in order to conduct experiments and tests. For the MEXT an approval among several ministries is mandatory in order to perform experiments for an early application of novel agri-biotech (Ma et al. 2016, 465). The permission of both the MAFF as well as the MOE ministers are necessary for environmental risk assessment, when GM plants are used in greenhouses or labs for biodiversity assessments. Corresponding with the required joint approvals, the environmental safety evaluations are also carried out by a joint expert panel consisting of both MAFF and MOE members (FSCJ 2015, 3).

When it comes to the policy for unapproved GM crops, Japan applies the zero-tolerance policy as well, which means that no trace of unapproved GMO material is allowed to be comingled among approved commodities. In recent years it has tried to synchronize its approval statues with their trading partners' in order to avoid trade disruptions, especially for often traded food commodities, such as maize and soybean. According to De Faria and Wieck, a synchronization process has occurred between the big exporting countries, and the importing countries with Japan among them (2016, 101).

In Japan, the risk assessments of GM foods are regulated under the “Food Sanitation Law” and remains a mandatory process within the GM crop adoption (Kamogawa 2018). The MEXT oversees tests conducted in laboratories for R&D purposes for all GMOs, including for food, feed, and other products. MAFF and MOE cover the assessment of environmental risks and possible impacts on biodiversity. While the MHLW assesses risks and safety of GMOs in foods, the MAFF overlooks the safety of GMOs in feed (Wang 2016). Therefore, the first step prior to submission of a new GMO’s proposal is to distinguish its purpose. Depending on its intended use, either the MHLW or the MAFF would forward a request to the Cabinet Office and food safety commissions as well as expert committees for tests for the submitted GMO (Sato 2010).

The tests for risk assessment fall primarily under the responsibility of the Food Safety Committee of Japan (FSCJ), which is an independent body under the Cabinet Office. Its main task is to assess risks to human health that are caused by “microorganisms, chemicals and others contained in food.” To reach this end, it runs risk assessments for the food and feed safety required by the MHLW and the MAFF (Sato 2018). The FSCJ collects data that is necessary to conduct risk assessments and has Scientific Panels and Advisory Committee to support its tasks. Scientific Panels process risk assessments on specific threatening foods, and the planning committee develops plans for risk assessment and risk communication (FSCJ 2015, 3). While the Scientific Panels are represented by researchers and academics from public institutions, the Advisory Committees include experts and stakeholders from a wide range of consumers and industries. The Advisory Committees oversee the decisions made by the Scientific Panels and forward their findings and opinions in a further step to the respective ministries. As a rule, the approval of a product is usually issued by the minister personally (Sato 2018; FSCJ 2015, 3).

Japan’s approval process leans towards the precautionary principle as well and used to focus on a purely scientific risk assessment conducted by specialists only. However, the government decided to expand its platform for decision-making to invite more decision-makers to participate in the evaluation. This strategy was primarily adopted in order to meet public concerns and foster consumer acceptance since the initial purely scientific method turned out to lack persuasiveness in this endeavor (Nishizawa and Renn 2006, 52). The earlier scientific discourse showed that even though in cases where apparent risks were not present, long-term risks can seldom be entirely ruled out for certainty either. The strategy of expanding and opening of the decision-making platform itself is already accompanied by the involvement of precautionary measures. According to Nishizawa and Renn, the transparency that Japan’s regulatory framework is known for is also reflected in the precautious elements in its approval process to foster public acceptance (2006, 52). Nevertheless, the earlier pragmatic approach resembling the US' approval efficiency prevails in GM crop imports to prevent trade disruptions (Ma et al. 2017, 465).

4.2.1.3. Intermediate results of approval process and risk assessment in China and Japan

Concerning the biosafety administration and approval process, China has been attempting to remove irregularities in its regulatory approval framework. In contrast, Japan shows more advanced approval regulations with transparent structure as well as a clear and efficient distribution of tasks among the respective departments. The Japanese institutions responsible for approval and risk assessment are compiled into different units that can be swiftly mobilized depending on the submitted new GMO's purpose and field of use. In China, the MOA carries the main weight for the approval process of agri-biotech products, including GM crops. While both countries currently still lean towards the precautionary principle as their primary type of approach for the approval process and risk assessment, their implementations still show differences. Especially in comparison, China seems to be approximating the EU's approach and tightening its rules, while some elements in the Japanese approval process reflect features known for the US approach, such as its efficiency of approving GM crops imports. In recent years, China received from both the government as well as the consumers increasing pressures that are reflected in its time-consuming approvals (Huang and Yang, 2014, 30; Ma et al. 2017, 460).

4.2.2. Labeling and Traceability in China and Japan

4.2.2.1. Labeling and Traceability in China

Even though China started as one of the pioneering countries in the field of biotechnology and initiated regulations in the early 1990s already, it did not start developing key regulations to coordinate R&D of agri-biotech until a decade later, even less regulatory aspects for the commercialization of GM foods (Gruére and Rao 2007, 53). In 2001, the State Council assigned the MOA with an update of agri-biotech regulations, specifically in regards to policies for GM in plants, animals, and microorganisms for agricultural use. However, even then, the regulations did not include labeling. The MOA, therefore, amended the former regulations and added, among others, labeling as an independent regulation (Zhang and Wang 2018, 314). In 2004, when China first adopted labeling regulations of GMOs, it was the only developing country that owned an effective labeling policy (Gruére and Rao 2007, 53)

Chronologically, China's labeling policy has its origin in the regulation of the MOST's measures for the safety administration of GM biotechnology in 1993. In 2002 the MOH issued "The Management Regulation on GMO Food Hygiene," which also required GM food to be labeled and marked another step towards mandatory labeling. This was followed by another regulation by the AQSIQ in 2004, which extended the scope of inspection on GM products to include traded GM goods. Based on the previously mentioned amendments, the MOA added several measures after having agri-biotech being assigned to it (Gilmour et al. 2015, 74). China's labeling regulation, therefore, has come a long way and involved in total four different governmental agencies, including the science, agriculture, health ministry, and the inspection and quarantine administration. Currently, China's labeling policy is regulated by the Food Safety Law, which was updated and implemented in 2015, and remains in the jurisdiction of the MOA. The new labeling law reflects a more stringent approach and requires mandatory GMO labeling for GM foods. In case of violation of these labeling rules, punishment can result in the form of fines or even license suspension. Despite the updated stringent law, there are no specific rules concerning the implementation of these labeling regulations, such as the font size (Wang 2016).

Officially the requirement for labeling of GM foods started in 2002 already, along with safety assessment and approval process. However, unlike safety assessment and approval process, labeling requirements have not been fully executed yet. According to the GM Platform of the FAO, China currently has a "mandatory and positive labeling regulation on GM food" (Fu 2018). A mandatory labeling system generally requires labeling for those food containing GM ingredients or produced by using GM materials during the process. A mandatory positive threshold requires labeling if the content of the GM component in the food reaches or exceeds a certain threshold. In contrast, a voluntary positive threshold indicates that the positive indicator can, but does not have to, be marked if the given threshold is exceeded (Vigani and Olper 2013, 34).

Although China has settled for a type of GM identification threshold, namely the previously mentioned mandatory positive threshold, it has not yet determined a specific percentage of the threshold for the positive mark, which makes the actual execution of labeling not properly feasible. The implementation of China's labeling policy is based on a list of specific GMOs and GM products that are required to be labeled. This list is conducted by the OBA under the MOA and encompasses "cotton seeds, soybean, corn, canola, tomato." Products that are derived from these GM plants in the form of oil, meal and flour, such as soybean meal, soybean oil, corn oil, corn flour, rapeseed oil, tomato sauce, require labeling as well (Zhang 2015, 255).

In China, labels are required on both the finished product as well as on products containing GM biotechnology in their production process. In terms of processed products that are derived directly from agricultural GM products, the label has to identify the main raw material that contains GM ingredients. The requirement of labeling is independent of the end test results and needs to be performed as long as the GM raw materials were used during the manufacture even if these GM ingredients are not detectable in the end product anymore (MOA OBA 2017). Gruère and Rao termed this approach in his research "process-based system" and the other approach as "product-based system" (2007). According to the information provided from the MOA OBA (2017) and Gruère and Rao (2007), China has a process-based system for labeling.

Building on the earlier detected information that China has a process-based system for labeling, the country's system for traceability can also be determined accordingly as an important component of the labeling enforcement. In China, any product derived from GM crops has to be labeled as much as the direct GM product of its origin, even though no traces of GM ingredients might be detected in the end product (Gruère 2007, 52). This requires advanced traceability behind the implemented labeling system in order for the country to trace GM ingredients in GM products from various actors, such as the farmers, operators to the retailers. Like many other countries with mandatory labeling regimes the Chinese labeling system also contains traceability of its GM products in order to track the origins of their components. Labeling and traceability of their end products, such as canola and soybean oils, are also required in China even if their final products are tested negative in their GM content (Yang 2003, 106).

According to Zhang, the absence of China's threshold setting next to its lack of scientific proof causes weak feasibility of its labeling regulation and, therefore, is in dire need for improvement.

The lack of threshold makes it difficult to follow the exact execution and determine a system of IP for these products, which usually would have been essential for the implementation of a stringent labeling system. The earlier mentioned list of commodities provided by the MOA does not include details of the approach towards China's labeling and traceability system (2015, 255). Therefore, Zhang advises to apply a scientific labeling and labeling threshold for GM foods based on the principles of "prevention, feasibility, economy and transparency" (ibid., 254).

4.2.2.2. Labeling and traceability in Japan

Japan applies a mandatory labeling regime that requires labeling of all foods that contain GM content that exceeds 5 percent, or when a GM ingredient is among the top three ingredients based on their amounts (Wang 2016). According to Zhang, Japan has set a positive threshold for its mandatory system (2015, 256). Gruère and Rao even go as far as to claim that Japan adopts a mixed mandatory-voluntary system. They explain that there are countries applying mandatory labeling for GM products with voluntary guidelines for non-GM foods and provided Japan and the EU as examples for this case (2007, 52). Voluntary labeling can be applied to those food products that are made "from non-GM crops that are segregated throughout the production and distribution stages" (Japan Food Industry Center 2002, 3).

Food labeling is handled by Japan's "Consumer Affairs Agency" (CAA), which is "a central administrative organization headed by the Minister of State for Consumer Affairs and Food Safety under the authority of Prime Minister" (CAA n.d.a). It reviews labeling regulations and is responsible for the protection and enhancement of consumer rights (CAA n.d.b., 3; Sato 2018). The latest food labeling act was enacted in 2015, which is composed of the "Food Sanitation Law," the "Health Promotion Law," and the "Japan Agricultural Standard" (JAS) Law" (Sato 2016). The joint implementation of these three acts covers, among others, the labeling of GM foods, which used to be primarily regulated by the JAS Law before 2015 and remained largely identical. The exact implemented labeling strategy depends on the components of the final food product and the amount of GM ingredients in it (Gruère and Rao 2007, 52).

Japan's labeling regulation depends on the GMO-content of food. If the end product contains GMOs, then labeling becomes a relevant issue, and its necessity can be determined by the quantification of GM ingredients. The threshold level for the labeling approach requiring labels on end products only tends to be higher compared to the labeling regimes that require every involvement of GMOs to be notified. Japan established a labeling threshold value of 5 percent for the non-GM products (Nikolić et al. 2017, 440; Sato 2016; CAA 2011, 5). This means that 5 percent is the impurity level that is allowed in foods without having to undergo labeling (Wang 2016).

While Japan requires labeling of all GM foods containing more than 5 percent GMO ingredients, those foods that do not contain any traces of GMO are allowed to apply a negative label promoting their GMO-free content. Japan's 5 percent threshold for GM content tolerance means that labeling is only mandatory if the GM component makes up more than 5 percent of the final product by weight, categorizing it as one of the "principal ingredients." If a food ingredient contributes to at least 5 percent of the total weight of the food, it accounts automatically for one of the "principal ingredients" the end product is made of. If the GM component makes it among the top three ingredients by weight of a final food product, then mandatory labeling would be required here as well (Sato 2018). The Japanese requirement of applying labels on the final food product only indicates the GM presence in the finished product as the labeling target. This means that only products containing traces of GM materials that can be detected in the final product require labeling (Gruère and Rao 2007, 52).

A product-based system, where the regulation targets the final product only, can be implemented by using testing and filter equipment (ibid.). Another tool is IP handling, which is required for all imported GMOs since these need to undergo strict segregation and labeling. Until 2015 Japan's labeling system for GM foods was regulated by the JAS law (Sato 2016), which provided labeling standards for GM foods as stipulated by the minister of MAFF (Goto et al. 2017, 353). It included also "identity preserved handling" or "IP handling" for foods containing GM ingredients (Japan Food Industry Center 2002, 1). IP handling is crucial for labeling of non-GM products, which is only allowed if no GM traits can be detected in the respective end product or if the end product does not contain more than five percent inadvertent GM content (Sato 2018). For example, in Japan, only non-GM soybeans are used for food and are separately imported and handled as IP commodities (Japan Food Industry Center 2002, 1). Currently, a composite IP handling system is available for specific commodities only, such as maize, potatoes, papayas, and soybean. For instance, GM potatoes or any product processed therefrom can only be imported if IP handling in accordance with the Japanese manual has been applied to the respective GM plant or processed product (ibid., 5). The process of IP handling starts at the farm level in the exporting country (Ebata et al. 2013, 147).

4.2.2.3. Intermediate results of labeling and traceability in China and Japan

In terms of labeling, China and Japan have more differences than similarities in their regulations. While both East Asian countries apply a mandatory labeling regime, Japan has added voluntary guidelines for non-GM food to its mandatory labeling regime (Gruère and Rao 2007, 52), which reflects Japan’s high demand for non-GM foods compared to China, where the consumers are more pragmatic in their purchases for food and primarily concerned about the pricing (Han et al. 2015, 8). While Japan has set its threshold strictly at 5 percent (Sato 2018), China’s lack of threshold is compensated with a list of very specific GM products that need to be labeled, including products that are derived from them. Another distinction can be detected in the labeling target, where China follows a process-based system (Gruère 2007, 52), while Japan targets the presence of GM ingredients in the end product (Sato 2018). The regulations for threshold level, labeling target, and traceability of both countries, show that China has more stringent requirements for labeling than Japan.

4.2.3. Coexistence in China and Japan

4.2.3.1. Coexistence in China

China does not have a coexistence policy for any crop farming systems (USDA FAS 2017). While inquiries have been submitted in the “13th Five-Year Plan for Science and Technology Innovation” to commercialize new domestic GM crops, such as “BT corn, Bt cotton and herbicide resistant soy by 2020,” no GM food crops have been cultivated domestically (ibid.). Nevertheless, according to Fu, China allows the production of GM food and feed for both commercial and research purposes upon authorization. The same rule applies for GM food or GM feed import (2018). Therefore, even though China is currently not cultivating GM food crops on large scale, it might do so in the near future, especially considering it having finally passed approval for domestic cultivation of GM corn and soybean earlier in 2020 (Gu and Patton 2020).

Apart from coexistence measure becoming increasingly a necessity in many countries, it would also be recommendable out of economic reasons for a nation managing several different farming systems at once. Based on Azadi et al.'s research, coexistence availability provides a country with additional benefits on the international market, since they offer the possibility of freedom of choice, which both producers and consumers appreciate (2017, 3). Since China has both available labeling regulations as well as traceability measures, it technically fulfills two regulations that crucially support the coexistence of different crop farming systems (ibid.). Nevertheless, apart from having a labeling and traceability system, China still has not adopted official coexistence measures yet.

China is one of the largest GM cotton producers in the world, however it has refrained from approving any major GM food and feed crops to be cultivated domestically. Next to the insect-resistant Bt cotton, disease-resistant papaya remains the only food GM plant that is being commercially cultivated. The main advantage that comes along the farming of GM cotton and GM papaya is the reduced chemical application to these crops. This reduction of chemical use has profited farmers by not only enhancing their income but also increasing their health by "reducing human and nontarget organism exposure to toxic chemicals" (Li et al. 2014, 565). In 2018 China cultivated 2.9 million hectares areas of biotech crops and ranked 7th among the GM crop planting nations (ISAAA 2018c, 4)

Apart from the limited GM crop cultivation, China is already managing organic and traditional, also known as conventional, farming systems. It is known as one of the top-five countries with the largest organic crop area (He et al. 2017). According to Song et al., China is in "transition from traditional agriculture to modern agriculture." The move towards developing modern agriculture has already caused rural restructuring in domestic grain production. Unfortunately, the change in crop productivity caused complications for farmers (Song et al. 2016, 2). During the modernization, especially farmers need education and access to the latest agricultural know-how to keep pace with the advancement in their own field. It is crucial for these services to be extended to rural areas for farmers to profit from the latest available agricultural technologies and new crop varieties (Jiao et al. 2018, 761).

Since China does not have any coexistence regulations, there are also no available mandatory crop segregation measures. The available rotation and intercropping measures represent alternative technical segregation measures and can substitute chemical pesticides. By preventing simultaneously mixing organic farming crops with conventional farming crops and cultivating them in succession, coexistence between different farming systems can be enabled. For example, soybean is the primary crop for organic farmers in China with a three years rotation, or until the soil productivity decreases, followed by one year of the less-demanding maize cultivation. Crop rotation is considered to be an effective strategy against pest, disease and weed and also advantageous for soil fertility management (Oelofse et al. 2011). While this rotation is feasible between traditional and organic crop farming, the cultivation of GM and non-GM crops in short rotations or contiguous fields would not be possible without more elaborate technical segregation measures (Vigani and Olper 2013, 34).

4.2.3.2. Coexistence in Japan

Japan fulfills most of the general requirements for coexistence and, thus, tends to be used as an example, next to the EU, New-Zealand and South Korea, for countries that would be capable of handling coexistence between different crop production system. This has been determined especially based on Japan's elaborate labeling system and traceability, which are both crucial administrative measures to reach coexistence. Countries that have an advanced labeling system and reliable traceability tend to be more successful in enabling coexistence. According to Azadi et al., countries that apply both labeling and traceability can expect more benefits on the international market and tend to be approached by more stakeholders, including both producers and consumers. Japan belongs to the beforementioned cases and is capable of offering freedom of choice regarding food crops from various farming systems (2017, 3).

The first coexistence strategy in Japan was established in 2006 in the form of the "Hyogo guidelines." The concept behind this strategy involved, on the one hand, a guiding policy for farmers who produce, distribute and sell GM crops, and on the other hand a guideline on labeling of GM products to meet consumer concerns. In 2007 the Japanese government established another set of guidelines, namely the "Kyoto guidelines," which regulated the farming of GM crops based on their already available food safety ordinance. These guidelines were intended for rice, soybeans, corn, and rapeseed and state that the cultivation of GM crops comes with the requirement to ensure prevention measures for cross-pollinating and commingling (Sato 2016).

Japanese crop farming consists of conventional and small organic farms (FAO/ITC/CTA 2001). Hokazono and Hayashi distinguish between the following three production systems in Japan: “organic, environmentally friendly and conventional” (2012, 101). Standard organic farming generally does not allow any use of chemicals, including synthetic fertilizers and pesticides, with very few exceptions for permitted chemicals, such as lime sulfur and low-synthetic minerals. Environmental-friendly farming in Japan requires 50 percent less amount of chemical fertilizers use than conventional farming and application of pesticides only half as frequently. Conventional farming has no strict rules to follow in this regard and is free to use chemicals, such as pesticides and synthetic fertilizer. However, according to the authors, the amount of used chemical pesticide and fertilizers have decreased compared to the last decades (ibid., 102). Japan currently does not use GM biotechnology for commercial crop farming but research only. The only GM plant Japan has been growing is the “blue rose,” which is a commercial biotech flower under “partially covered conditions” and not in the open field like the traditional GM food crops in other countries. Even though Japan is still not growing GM food crops, it has always been a forerunner in measures concerning coexistence (ISAAA 2016, 7; Kamogawa 2018). Since the emphasis of the factor of coexistence lies on the country’s capability and not necessarily the implementation of the named measures, it can be concluded that Japan fulfills the general coexistence standards.

Apart from the absence of GM crop farming for commercial purposes, Japan has only limited production of organic crops due to scarcity of arable land. Farming in Japan is also difficult due to the country’s hot and wet climate conditions. Nevertheless, the agricultural products grown domestically show a wide range of varieties, including “rice, green tea, green vegetables, sweet potato, taro, pumpkin, potatoes, citrus and many other fruits” (FAO/ITC/CTA 2001). Most of Japan’s agricultural market for food and feed crops is dominated by conventionally grown products (Hokazono and Hayashi 2012, 102). In 2001, only 0.2 percent of 2.5 million Japanese farmers were organic farmers. However, conventional farms have experienced a decline in the 2000s (FAO/ITC/CTA 2001), while Japan’s organic agriculture is receiving promotions from its government, since it achieved its goal to double its organic farming. In the recent years, 0.6 percent of cultivated land in Japan is used for organic agriculture and the nation’s goal lies at 1.0 percent (MAFF 2017).

In 2004 the MAFF issued requirements for different plant species that involved crops from various farming systems, including GM and non-GM plants. These requirements encompass the establishment of buffer zones for GM crops in open fields as a prevention measure for cross-contamination of various crops through pollen, which is also known as "cross-pollinating." Each crop has been assigned with its own "minimum isolation distance," which can vary from 10 meters for soybeans, up to 300-600 meters for corn and rapeseed, depending on the presence of windbreak. The minimum isolation distance for rapeseed lies at 600 meters. This regulation is only relevant for the beforementioned crops with food and feed safety approvals (Sato 2010). Coexistence measures, while important in general for in the field of GMOs, is not necessarily relevant for Japan, since it "produces GM food and feed only for research purposes" only (Kamogawa 2018).

4.2.3.3. Intermediate results of coexistence in China and Japan

Both China and Japan have conventional and organic farming systems; however only China is actively cultivating GM crops. While Japan again owns the more elaborate regulatory requirements in advance, it has still not started domestically producing GM food crops. Already in 2006, Japan adopted its first coexistence measures in the form of Hyogo guidelines (Sato 2016). In the meanwhile, China is cultivating both GM cotton and GM papaya in a small area next to its existing conventional and organic farming systems, but still has not adopted any advanced crop segregation measures (ISAAA 2017, 42). Coexistence regulation puts Japan's general approach with China's in contrast. While Japan, once again opts for the more thorough administrative and technical measures in advance, China adopts these measures upon necessity. This procedure might sound familiar considering China's approval process as well, causing it to be more susceptible to AA situations (De Faria and Wieck 2016, 87).

4.2.4. Membership of international agreements in China and Japan

4.2.4.1. Membership of international agreements in China

China signed the Cartagena Protocol in 2000 and ratified it in 2005 (SCBD 2016a). It introduced necessary legal and administrative measures in the form of a national biosafety framework following the Protocol, which became fully operational by 2001. China was among the countries that participated in the Fifth Meeting of the Convention on Biological Diversity at which the signing of the Cartagena Protocol had first taken place. The East Asian country fulfills most of the "General Provisions" in Article 2 that are listed in the CPB. For the implementation of China’s national biosafety framework, several national biosafety regulations and sets of biosafety guidelines are in place. There is no mechanism for the allocation of funds for the execution of this national biosafety framework. However, China has permanent staff members who are tasked with its administration. As required, China has implemented Article 2 by establishing several bodies in relevant authorities tasked with biosafety management, such as the National Biosafety Administration Office in the MEP or the individual division under the MOA for biosafety regarding GMOs and intellectual property rights. In regards to Article 6 concerning transit and contained use of LMOs, China executed relevant adoptions in the form of the “Regulation on Biosafety Management of Agricultural GMOs” that addresses agricultural GMOs in various aspects, such as trade, research, and production and processing (Jing 2015).

China’s food safety legislative framework has been undergoing changes over the past 50 years, and modernization of it came along when the country identified the very subject of food safety as a national priority. The country’s main objectives currently include protection of human health, prioritizing risk analysis principles, and scientific assessments in decisions concerning food safety standards and the compliance to China’s obligations towards the World Trade Organization (WTO) (Zhang et al. 2018, 106). China’s current national food safety standards were established under the guidance of the Codex Alimentarius Commission (CAC), which China joined in 1984 (FAO/WHO 2019a).

The CAC supports developing countries by offering assistance with the adoption of food safety standards while considering the respective nation’s background. In the case of China, the CAC provides standards with allowances for fast development of food production while taking its consumer expectations into account. China has currently uploaded 427 regulatory texts on the Codex’s official database for national legislation that is in accordance with the CAC’s principles (FAO/WHO 2020a). The CAC advocates the application of scientific evidence in terms of developing food safety standards, which again is an approach in compliance with China’s endorsement. The Codex not only calls for its subscribers to adhere to the provided international standards but also advises them to maintain continuous revisions and improvement in their national food control systems. In terms of structure and operations, China’s food safety standards are modeled in accordance with the Codex as well, which provided the country with a solid fundament for future developments and necessary expansions. For example, China’s food safety standards development is also based on eight steps, just as the “Codex step procedure,” that calls for repeated revisions, amendments and re-evaluations by administrative and other relevant bodies (Zhang et al. 2018, 108; WHO and FAO 2018, 17).

The adoption of best practices offered by the Codex in the fields of design, operations and implementation of food safety standards should not only encourage further adaptions and thus improvement of the current food regulation system but also prevent food safety casualties in the future (Zhang et al. 2018, 106). However, while the general approach seems to be for a good cause, criticism can be found in its execution. According to Jia and Jukes, Chinese national standards, while considering the Codex’s guidelines, frequently allows amounts for contaminants that exceed the allowed maximums (2013, 243). However, since the Codex texts are recommendations only, the applications of their standards and guidelines remain all on a voluntary basis (WHO and FAO 2018, 9).

4.2.4.2. Membership of international agreements in Japan

While the date of Japan’s signature is not available, it has been noted at the Biosafety Clearing-House (BCH) that Japan ratified the CPB in 2003, and within a year the Protocol came into force (SCBD 2016b). Japan fulfills many of the general requirements of the protocol. It is an official party to the CPB and has a domestic regulatory framework fully in place to carry out legal and administrative measures that are required for the implementation of the Protocol since 2004. Several national biosafety laws are also in place to enforce the beforementioned regulatory framework. Japan does have budgetary allocations of funds specifically for the national biosafety framework and permanently staffed members who manage the national biosafety framework. For more transparency, it also submits its biosafety framework, including laws, regulations, and guidelines, to the BCH, a facility established by the Protocol for the exchange of information and assistance in implementing the Protocol. Seven ministries are involved in the execution of the Protocol with full-time staffed members who manage a budget for the Protocol’s adoption into the domestic law. Regarding article 6, Japan officially does not have regulations for the transit of LMOs. However, in order to prevent the disposal of LMOs into the local environment, Japan has containment measures, which are stipulated by the competent ministry or minister depending on the specific circumstance (Somiya 2015).

Japan has been a member of the CAC since its foundation in 1963 (FAO/WHO 2019a) and currently has uploaded 15 regulatory and legislative texts, including regulations on standardization of proper labeling, food safety assessments, and food sanitation on the Codex' platform available for public access. Recent enforced acts include acts on food labeling in 2014 and safety assessments of GM feed in 2004 (FAO/WHO 2020b). With increasing globalization and the rising volume of traded goods, the implementation of the food safety standards provided by the Codex remains more relevant than ever for Japan. The Codex offers validated analytical methods that are applicable for international regulatory analysis according to the CAC. These were adopted in the Japanese Agricultural Standard (JAS) by the MAFF in the face of Japan's increasing trade due to rising needs for food supply but also to improve international business (Hakoda 2010, 134). As one of the first East Asian countries to join the CAC, Japan hosted the first coordinating committee for Asia during its time of national promotion of biotechnology (Yamaguchi and Suda 2010, 390). Japan has been actively involved in meetings since 1996 when it first hosted the "FAO/WHO Coordinating Committee for Asia" as one of the pioneers among Asian countries to have joined the Codex's cause. In the following years, Japan actively hosted meetings for a task force of the CAC, specifically for foods made from biotechnology (FAO/WHO 2019b).

4.2.4.3. Intermediate results of membership of international agreements in China and Japan

Both China and Japan have embraced the Codex Alimentarius as well as the Cartagena Protocol. While Japan approached both agreements at the earliest time, China has not remained far behind either. A difference between those two country cases can be detected in their submission of biosafety regulations to the BCH. While Japan submits its biosafety laws, regulations and guidelines to the BCH (Somiya 2015), reflecting its general transparent approach in regulatory aspects of biotechnology used for food (Ma et al. 2017, 464), China does so only partially and with more reluctance (Jing 2015). However, regarding the transit of GMOs, it is China that has implemented regulations, which Japan has refrained from so far (Jing 2015; Somiya 2015). An outstanding difference regarding their membership with the Codex Alimentarius would be China's three-digit national legislative texts in compliance with the CAC, while Japan only has 12 (FAO/WHO 2019b). However, the discrepancy of these numbers does not necessarily reflect the comprehensiveness of each country's adoption of the regulations as much as each country's different approach.

5. Analysis

5.1. Comparative assessment of influencing key factors before the adoption in China and Japan

5.1.1. Comparative assessment of ministerial control of biosafety in China and Japan

When it comes to jurisdiction over biosafety, these two East Asian country cases distinguish themselves from each other in several organizational components while still sharing similar approaches towards biosafety. China's agriculture ministry, the MOA, officially has the leading position in issues concerning the biotech sector, including the primary responsibility in terms of biosafety. There are additionally six other governmental agencies involved, such as the ministries of environment, commerce, S&T, the commissions for national development and national health (Ma et al. 2017, 461). The MOA is responsible for the approval of GM crops and makes decisions about their trade and domestic production. It is the leading department for the development of national policies concerning agri-biotech and its products for food and feed (USDA FAS 2017). Japan has four ministries involved in the management of biotechnology and its products, including the ministries of agriculture, health, environment and S&T. The MOE has a similar leading function as China's MOA, although with less authority (Alien species and LMO Regulation office et al. n.d., 8). However, despite Mabaya et al.'s theory that ministries of environment tend to view GM crops more critically and be less eager to promote biotechnology policies (2015, 581), Japan's MOE showed earliest enthusiasm in advancing biotechnology similar to China's MOA.

Japan's structure of ministerial control over biosafety also defied Mabaya et al.'s prediction of administrative inefficiency with higher numbers of involved ministries. The authors argued that, despite advanced scientific infrastructure, a higher number of involved ministries in the examination and approval process would slow down the whole adoption process and raise its cost (2015, 581). However, Japan managed to remain one of the countries with the most advanced biotechnology sectors. Even though the Japanese administration involves a total of four ministries, they have a clear allocation of responsibilities, and are all involved in biosafety issues. Each department will only be invoked under specific circumstances, with the exception of the MOE, which is involved in all issues concerning GMOs (Sato 2016; Wang 2016).

According to Kou et al., the orientation of a country's biosafety administration, especially in terms of GMO, lies not necessarily in the applied measures, but originates from "the guiding principle of GMO safety evaluation" (2015, 2158). This principle tends to be represented by the leading institution's motivation that has the most authority over biosafety related issues. The motivation behind the primarily involved institutions of both countries turned out to be similar due to the shared main goal of the leading ministries. China's MOA has the primary responsibility for overseeing development in agriculture and rural areas. With agriculture at its core, which is at the same time a priority for the Chinese government, the MOA is tasked with leading authority, especially in agriculture and productivity-related matters. Its motivation lies in the improvement of productivity of farmland and labor and efficient utilization of resources. The MOA actively manages and promotes agri-biotech as a tool to reach its targets for higher grain production and modern agriculture (Gilmour et al. 2015, 80). In Japan, the MOE is the leading entity that is involved in all subjects concerning biosafety. Among its primary task is the promotion of environmental policies (Alien species and LMO Regulation office et al. n.d., 8). Due to its practice-oriented mechanisms on reaching sustainability, the MOE shows a high level of willingness to cooperate with other institutes and promote of R&D, especially for technologies that forward sustainable development (AECEN 2018).

Similarities between China and Japan can be detected in the structure of ministerial control, when looking beyond the main leading institute, including fellow involved departments and the range of their involvement. While each different ministry has its own individual motivation, many share the common goal of national welfare regarding their interests in GM biotechnology. Both countries have a pragmatic approach towards biotechnology, which is considered a major incentive for stakeholders, next to the joint meetings and conferences, that are used as platforms for further information exchange and input. China and Japan's biosafety policies share a similar stage since they both have all three recommended national policies of Burachik and Traynor covered (2005), although they differ in their implementation. Both have signed the Cartagena Protocol, and are promoting the safe use of biotechnology products by applying thorough risk assessment measures. Japan is renowned for its technology-first approach and has stayed mostly true to this course for a long time until the rise of civic concerns (Holroyd 2014, 7). China's pragmatic approach has experienced some similar decelerations in the recent years, due to growing consumer resistance (Zhang and Wang 2018, 318).

Criteria	Indicators	China
• Jurisdiction over biosafety	– Number of ministries and departments – Major institutions involved in biosafety	→ 7 governmental agencies + 2 councils → Primary: MOA Secondary: NDRC, MEE, MOFCOM, MOST, NHFPC, AQSIQ
• Motivation behind primary involved department	– Approach to biosafety – Interests and concerns	→ Scientific-based approach → MOA: to improve farmland productivity and resource utilization
• Stage of biosafety policies	– Promotion of biotechnology and its products – Risks assessments of environment and health – Involvement of stakeholder input	→ Promotion of safe use and GM products by MOA → Determined at JMC led by MOA → Through JMC and NBC
Criteria	**Indicators**	**Japan**
• Jurisdiction over biosafety	– Number of ministries and departments – Major institutions involved in biosafety	→ 4 ministries → Primary: MOE Secondary: MAFF, MHLW, MEXT
• Motivation behind primary involved department	– Approach to biosafety – Interests and concerns	→ Technology-first approach → MOE: Sustainable development
• Stage of biotechnology policies	– Promotion of biotechnology and its products – Risks assessments of environment and health – Involvement of stakeholder input	→ Promotion of R&D of crop biotechnology led by MOE and MAFF → Determined at Stakeholders' Meetings led by MOE → Through Stakeholders' Meeting

Table 8: Results of comparative assessment of ministerial control of biosafety in China and Japan

5.1.2. Comparative assessment of advocacy by key political figures in China and Japan

According to Mabaya et al., strong views from a country's leading political figures and other senior political figures can have a crucial influence on public policy and their implementations. A political figure, who is in favor of biotechnology, can not only support a country's R&D of this sector but even accelerate the relevant regulatory procedures, such as approval for commercialization of GM crops. Among senior political figures, especially the health, environment and agriculture ministers' stances on biotechnology can be crucial for the potential of agri-biotech and GM crop adoption in a country (2015, 583). Burachik conducted similar observations and stated the importance of an encouraging R&D policy environment, especially at the early stage of the development of agri-biotech and a successful GM crops adoption (2010, 589). The attention of the political leadership and the investments that come along with it can generate both incentives as well as pressure on scientists and government agencies who asked for funding. These reactions again can increase motivation for both scientists and bureaucrats to jointly head towards the commercialization of new GM crops (Cao 2019, 74).

Both China and Japan started developing GM technology and GM crops early on and are two pioneer GMO adopting nations. The advocacy by China's leadership dates back to the term of Xiaoping Deng, the first Chinese leader, the MOST considers of having the necessary "strategic vision and resolution" to implement and advance high-tech development, including agri-biotech in the 1980s. The 863 Program he introduced in 1986 provided China with an overall boost in high-tech development. The initial goals for adopting this biotechnology included the improvement of the nation's food security, promotion of sustainable agricultural development, and increasing farmers' income (MOST n.d.a.). These goals resemble Japan's original intentions for its adoption of GM biotechnology when the debates were first launched in the 1970s under Prime Minister Takeo and continued under Prime Minister Masayoshi. Among the Japanese political leaders, Prime Minister Koizumi is one of those who showed most openly support towards the advancement of biotechnology. He founded the Biotechnology Strategy Council in 2002 and announced the adoption of biotechnology as a means to improve Japanese people's lives and increase industrial competitiveness. Several new GM crop varieties got approved for human consumption during his office term, including several GM corn and soybean varieties (Cabinet Public Relations, Office Cabinet Secretariat 2002; Tiberghien 2006, 26).

In recent years, however, Japan redirected its course under Prime Minister Abe towards innovative biotechnology and its use in sectors beyond agriculture. Therefore, the term “GM biotechnology” specifically has not been mentioned as a priority in Japan’s recent S&T Plans since Abe came to office. China, on the other hand, did not waver since the Deng administration when it recognized biotechnology’s potential. It additionally raised the nation’s competitiveness in the international agricultural market and created a modern market-responsive R&D system without dismissing GM biotechnology as a tool to ensure food security (Huang and Wang 2002, 123; MOST n.d.a.). Its current leader President Xi also showed his active support towards strengthening research and innovation of GM crops (ISAAA 2017, 44).

Internal political agreement or disagreement can have a crucial influence on politicians, who tend to change their stances towards enacting and expanding GM technology depending on the approving or disapproving political and public environment they are surrounded with (Mabaya et al. 2015, 585). In China, political unity is provided and reflected in the consistency of politicians’ statements. Among the supporting leaders were the Premier Zhu and Premier Wen, whose advocacy for biotechnology allowed the accumulation of public funds through a series of programs designed explicitly for S&T. Consistency can also be detected between deputy director Chen’s and Han’s statements, both in accord with President Xi’s. All of them offered their consent that China should remain one of the frontrunners in transgenic technology while disapproving excessive foreign products in the domestic GMO market (Cao 2019, 50).

The Japanese central government also adhered to its consensus for biotechnology as a priority for economic growth, which remained overall intact despite the growing civil society movements against GMOs by the turn of the century. At the rise of civic concerns, local governments took the hit first, while Japanese politicians from the central government remained supportive of agri-biotech and the adoption of GM crops. The LDP diet member Omi Koji kept actively promoting agri-biotech throughout the 1990s, first under Prime Minister Yoshiro and then under Prime Minister Koizumi in the 2000s. Both prime ministers gave their consent and support for Koji and advocated for Japan to remain among the main actors in biotechnology R&D and industrial development (Tiberghien 2006, 26).

Public opinion is another policy driver that has proven to be a much stronger influence on politicians than science (Mabaya et al. 2015, 585). This phenomenon can be observed in both China as well as in Japan. The doubts and debates involving the technology seemed to be recognized and responded by Chinese politicians while emphasizing the necessity of biosafety and the rewards that could be brought by domestic innovation (Cao 2019, 74). Civic concerns are addressed by politicians like Han through the application of rigorous regulations and strengthening of supervision, however, without compromising the respective national policy. Concerns about GM foods specifically have risen in China, leading the government to introduce the requirement of labeling in 2002 (Gilmour et al. 2015, 74). However, the government's pursuit of staying as a frontrunner in agri-biotech remained unchanged.

Unlike China, Japan appears to be more susceptible to consumer resistance (Nishizawa and Renn 2006, 49). Since the coordinated anti-GMO actions in 1999, that triggered off consumer campaigns in the following years, GM biotechnology turned into an infrequently addressed topic by Japanese politicians. Civil society can only exert pressure but not execute actual agri-biotech regulations, which are implemented by the MAFF and the MHLW (Tiberghien 2006, 27). Similar to China, Japan also responded to civic concerns with strict regulations, such as the immediate introduction of mandatory labeling (Nishizawa and Renn 2006, 47). However, the Japanese government yielded much more of its initial designated priorities for biotechnology than China.

Japanese politicians are more susceptible to civil society movements since they are more dependent on public approval and their ability to cause shifts in voting. The situation became increasingly critical when regulation of GM biotechnology and GM crops started influencing voting intentions in urban areas (Tiberghien 2012, 116). Even though statements specifically against GM crops and GM biotechnology have not been detected among the ministers with key positions so far, decreasing attention for GM biotechnology can be witnessed throughout the past decade, such as its omission in relevant national S&T plans. Another evidence would be Japan's abrupt transfer of debates on agri-biotech from a scientific to a public platform, which coincided with Japanese consumer campaigns' peak and coordinated anti-GMO campaigns since 1999 (Nishizawa and Renn 2006, 46).

In China, civic concerns are addressed by politicians with regulatory measures demanded from consumers as well; however, without changing China's main course of national policy on transgenic technology. Chinese deputy director Han advocates for both transgenic technology and also consumers' rights, while demanding the dissemination of accurate knowledge on complicated scientific issues, such as biotechnology and its use for the daily life of citizens (Cao 2019, 49).

Mabaya et al. also addressed the advocacy and opposition of ministers from crucial sectors. Especially ministers of health, environment, and agriculture can drive public policy for agri-biotech and GM crops (2015, 583). This phenomenon can especially be detected among Chinese ministries. The Chinese MOA is an influential ministry that leads the inter-ministerial joint meetings for agri-biotech policies with twelve different departments (Kou et al. 2015, 2160). The Japanese MAFF also has the upper hand in issues concerning crop biotechnology (MAFF n.d.), although the MOE has a broader influence in terms of biosafety since it is involved in all fields concerning products resulted from biotechnology (AECEN 2018).

A comparative analysis the factor of advocacy of key political figures turned out to be difficult and unbalanced due to limited availability of ministers' and political leaders' stances from both countries on the specific subjects of GM crops and agri-biotech. Among the available stances, no clear opposition or even reluctance against agri-biotech or GM products has been detected among political leaders or ministers. Resistance movements can primarily be found among consumers in the form of anti-GM lobby campaigns in both countries, although the voices in Japan are much louder than in China. Many recent Chinese and Japanese politicians do not have a clear available statement on GM crops specifically. Chinese and Japanese politicians seem to be much more cautious concerning their statements; however, China's approval towards biotechnology and GM crops have increased again under the Xi administration. Resistance or lack of support from politicians and leaders seems to be available at most in the form of absence of funding for R&D or lack of prioritization. Japanese ministers have been overall supportive towards biotechnology; however, the recent focus has been redirected towards more innovative technologies and biotech's use in other fields, such as regenerative medical treatments (Kawano and Matsuyama 2013; The Biotechnician 2015). GM biotechnology and its use as a domestic tool to enhance food security have been increasingly neglected, although Japan continues to import GM crops to cover its food demands.

Criteria	Indicators	China
• View of political leaderships	– Stance on R&D in agri-biotech – Opposing or approving opinion of GM crops	→ General Secretary Deng: approved GM biotech since the 1970s → Premier Zhu and President Hu: pro-agri-biotech in the 1990s and early 2000s Promotion of sustainability through biotech in 2000s → Premier Wen: advocate for GM crops and agri-biotech in 2008-2010 → President Xi and Premier Li: released policies promoting biotech in 2011 active support of GM biotech in 2016
• View of other senior political figures from key departments	– Stance on R&D in agri-biotech – Opposing or approving opinion of GM crops	→ Deputy director Chen: advocate for agri-biotech development in 2013 → Deputy director Han: advocate for GM crops, biosafety since 2015 → CPPCC member Chen: pioneer advocate for GM crops
Criteria	**Indicators**	**Japan**
• Prevalent view of changing leaderships	– Stance on R&D in agri-biotech – Opposing or approving opinion for GM crops	→ Prime Minister Ryutaro: openly supported GM crops in Diet negotiations in 1997 → Prime Minister Koizumi: advocated for R&D in biotechnology since 2002 → Prime Minister Abe: restored competitive biotechnology since 2013
• View of other senior political figures from key departments	– Stances of ministers from key departments – Endorsement or opposition towards R&D	→ Minister of S&T Koji: leader of biotechnology lobby in 2000s → MAFF minister Takebe: co-founded NIAS for GM crops in 2001 → FSCJ Chairperson Satoh: science-based assessment in 2015 → MOE director Morishita: pro biotech in 2018 → MAFF minister Yoshikawa: pro agri-biotech at G20 meeting in 2019

Table 9: Results of comparative assessment of advocacy by key political figures in China and Japan

5.1.3. Comparative assessment of peer country influence in China and Japan

Peer country influence inevitably occurred in East Asia as well, as predicted by Mabaya et al. for other countries, although the consequences and effects might not have been as prominent as for other cases. China and Japan received influence from a similar group of countries, with North American nations as front runners. These not only encouraged, but also pressured the two East Asian countries into adopting regulations more align with their own. However, China and Japan both influenced with their own GM biotechnology adoption other nations as well, but did not cause the “domino-effect on neighboring countries,” mentioned by Mabaya et al., which was more relevant for regions like Africa with more “porous borders” between the neighboring countries (2015, 582). On the one hand, China and Japan observed neighboring nations for policy guidance, but on the other hand, they also functioned as role models once they have acquired modern biotechnology. The politics of biotechnology are known to be susceptible to pressure from other governments and commercial interests. They can shape how a nation domesticates its commitments (Newell 2008, 126). As Vigani and Olper predicted, especially labeling and approval process of GM foods are sensitive regulatory aspects prone to peer country influence (2013, 34). Both regulatory aspects in China and Japan fell subject to the US’s and the EU’s influence.

North American nations’ choices and approaches towards GM biotechnology influenced both East Asian country cases, though in different ways. Peer country influence from modern Western countries, especially the US and the EU, arose to an inspiration Japan attempted to follow. It triggered Japan’s competitiveness to strive towards the same results that R&D in S&T and biotechnology have brought the US, which were both noted in Japan’s S&T Basic Plans (Cabinet Office, GOJ 1996; ibid. 2001, 19; ibid. 2006, 3). As a cooperation partner, the US invested in Japan in the 1980s for joint projects of seed development. China took note of the US’s advancement in the agri-biotech sector and initially borrowed elements from its regulatory framework, next to Japan and the EU’s, to improve its own risk assessment process (Newell 2008, 124). Compared to Japan, the US’s predominant influence on China took a less inspirational and more pressuring turn by trying to convince China to apply fewer complex regulations to ease trade in the face of China’s growing food demand and increasing market for GM crop producers (ibid., 125).

Vigani and Olper predicted that especially developing countries would be prone to give in and adapt their labeling regime to peer countries' regulations (2013, 34). In this regard, both China and Japan's regulations for GM biotechnology and their products continuously assimilated with the EU's precautionary principle. By attempting to meet European standards, China increased its compatibility for trade to receive access to the European market (Newell 2008, 120). Japan followed the European regulatory approach as well, however, primarily because European safety standards' capacity can fulfill Japanese domestic needs and civic concerns (Wong and Chan 2016, 127).

China and Japan have not only received but also emitted peer country influence, as two of the countries most experienced with GM biotechnology, causing others to follow their lead. This phenomenon can be witnessed in South America, where the biggest GM crop-producing countries nowadays reside. Here China and Japan both had important but different influences on the countries in the southern cone. China did not consciously convert South American countries to adopt GM crops, unlike Japan, that actively introduced food commodities with potential for an upgrade by GM biotechnology adoption (Oliveira and Hecht 2016). China did not actively insert or promote GM crops but instead offered a cause for South American countries, like Brazil and Argentina, to increase their crop production, especially for soybean (ISAAA 2017, 17; Leguizamón 2014, 152). In order to meet China's rising food demand for trade and the benefits that come along it, GM biotechnology arose to the occasion.

Unlike China, Japan had an active role in the beginnings of South America's GM crop adoption and literally planted the seeds for it. Initially, soybeans did not even fit into Brazilian diets and were only consumed by Japanese migrants. The demand for the oilseed industry was also limited in Brazil. However, what used to be simply an immigrant subsistence crop soon became instrumental to the global expansion of soybean production in South America (Oliveira 2016, 350). Japan not only provided the commodity of soybean itself to Brazil but also actively invested into its expansion by offering credits and technical support for the required agri-biotech (ibid., 356), as well as trilateral collaborations with the third-party Mozambique (ibid., 359). While China introduced neither the technology nor the crop varieties to Africa, its successful agri-biotech sector seems to represent an aspiring example for developing countries among pro-GM advocates. Despite the differences between the developing countries, some researchers believe that nations like African countries, India and Bangladesh could reach similar success like the benefits China experienced by following developed economies (Paarlberg 2010, 612; Jiao et al. 2018, 761).

Within the Asian region, China and Japan developed each of their agri-biotech sectors independently without crossing each other's paths in their initial stages until regulatory frameworks became critical. China was influenced by Japan's regulations for GM biotechnology and adopted elements from the Japanese approach, which was one of the first and most advanced frameworks available during the rise of GM biotechnology and its products next to the regulations of the US and the EU (Newell 2008, 124). In general, both East Asian countries favored the European approach of the precautionary principle for their regulations, especially concerning risk assessment and approval process. The "wait and see approach" observed by Mabaya et al. in Africa (2015) can be observed between China and India at the rise of GM cotton adoption. India has been criticized for having missed the opportunity to surpass China due to its reluctance to its investors in the expansion of GM cotton, who remained for too long "waiting and watching" (Newell 2008, 121).

Criteria	Indicators	China
• Received influence from senior and fellow GM crop adopters	– GM crops adopters that influenced China – Received GM policy and regulation guidance – Application of wait-and-see approach by China	→ The US, the EU, Japan → The EU's precautionary principle → Not applied by China
• Emitted influence on pending and fellow adopters	– GM crop adopters influenced by China – Emitted GM policy and regulation guidance – Application of wait-and-see approach by fellow adopters	→ South American soybean producers and India → Not detected → Applied by India
Criteria	Indicators	Japan
• Received influence from senior and fellow GM crop adopters	– GM crops adopters that influenced Japan – Received GM policy and regulation guidance – Application of wait-and-see approach by Japan	→ The US, the EU → The EU's precautionary principle → Not applied by Japan
• Emitted influence on pending and fellow adopters	– GM crop adopters influenced by Japan – Emitted GM policy and regulation guidance – Application of wait-and-see approach by fellow adopters	→ Brazil, Bolivia, Argentina, Mozambique → Model for developing countries' risk assessment, such as China → Not detected

Table 10: Results of comparative assessment of peer country influence in China and Japan

5.1.4. Comparative assessment of technical capacity of China and Japan

The technical capacity reflects a country's competence and willingness to handle a certain level of technology (Mabaya et al. 2015, 583). It depends on the country's progress in S&T and the priority it reserves for innovation and development of key industries, which can include biological, agricultural, pharmaceutical and other relevant technologies (Zhang et al. 2018, 110; MOST n.d.a.). By offering research platforms for enhancing agronomic traits, such as improved yield, quality and stress tolerance, and diversifying methods for crop improvement, a country shows its capacity to maintain current technical requirements and the possibility of room for advancement (Xu et al. 2017, 97). Both nations show interest in agri-biotech development by investing financial and human resources in the advancement of key industry technologies, such as the seed sector, and establishing national entities for its management and promotion.

The similarity of both countries' approaches lies in some of their identical goals, such as the pursuit of food security through a reliable supply of agricultural products. The differences can be observed in each country's focus on the specific field within agri-biotech advancement. The innovation of S&T in China is supported by three ministries, including the MOA, the MOH, the AQSIQ, and the State Council (Gilmour et al. 2015, 74). In Japan, innovation is managed by the CSTI under the guidance of the Prime Minister and in accordance with the MOST's policy (Cabinet Office, GOJ 2017a, 4). According to Mabaya et al., the placement of oversight of a regulatory area can have a crucial influence on the priorities and direction of biotechnology's development (2015, 581). In terms of innovation, Japan has vested the lion's share of authority in one council prioritizing S&T advancement (Cabinet Office, GOJ 2017a, 4), while in China, up to four entities share this responsibility, which is led by the MOA and followed by the MOST (Gilmour et al. 2015, 74).

Furthermore, the two countries' priorities are also characterized by disparities caused by the leading institutions' agendas. Japan seems to be more focused on the R&D of technologies as a tool, such as efficient crop production and gene-editing methods and less about the products resulting from biotechnology (Cabinet Office, GOJ 2017b, 46). In terms of innovation in the agricultural science sector, especially the products derived from novel technology, Japan shows a case-by-case approach, which again restricts the efficiency of innovation (Ishii and Araki 2017, 46). On the other hand, China seems to prioritize the R&D of food products resulting from biotechnology, particularly those relevant to national food security (Gilmour et al. 2015, 77). Innovation is led by the MOST and the MOA, with the MOST promoting base research and the MOA transforming the achieved scientific R&D into industrial capacity and implementing them on agricultural food products. Examples of this implementation are China's seed sector or innovation of related areas to biotechnology, such as advancements in field management, which can increase agricultural productivity (Hu et al. 2017, 127).

Sustainable agriculture can only be achieved if there is a cooperation between crop research, seed development, and an efficient distribution system that enables farmers to receive quality seeds in time (FAO 2010, 23). Both East Asian countries seem to have heeded these pieces of advice in general; however, Japan has a head start since the 1980s with collaborations with the US in the pursuit of new seed varieties. China's focus on sustainable crop production encompassed seed sector development as a key factor in achieving a reliable agricultural food supply. The importance of S&T of the seed sector has also been explicitly addressed in the 12th Five-Year Plan with the goal of discovering new possibilities for plants with improved yields, resistance, and adaptability (Gilmour et al. 2015, 78). Furthermore, through seed research China also hoped to increase its crop varieties and achieve modern farming through one more alternative approach. China is a leading nation in R&D of rapeseed, hybrid rice, and food legumes. Especially its advancement in food legume production reflects its advanced seed-handling capacity (Li et al. 2016, 115). In the meanwhile, Japan is more focused on the R&D of seed technology with its modern seed supply centers as evidence. One of the main goals of R&D of the seed sector relevant to both countries is the achievement of high-yielding seeds for reliable food supply (MAFF 2008; Xu et al. 2017, 97).

NBC is considered by Mabaya et al. as an essential national authority to oversee biosafety, and its existence is another factor that correlates with the advancement of a country's biotechnology sector (2015, 588). A national committee can collectively manage administrative arrangements for biosafety or GM food safety (Okeno et al. 2013, 128). China's NBC was founded in 2012 and is tasked with conducting safety assessments for the MOA (Kou et al. 2015, 2160). Japan has an NBC as well in the form of the FSCJ, which is created in 2003 already and encompasses the Expert Committee of GM Foods to conduct safety assessments. Unlike China, Japan's committee conducts food safety risk assessments for the MHLW and not its MAFF (FSCJ 2015, 2), signifying a diverging focus of the very assessments, since each ministry has its own priorities and agendas. While China's NBC is dominated by the MOA and prioritizes agricultural issues, including agricultural GMOs, next to environmental and food safety, Japan's FSCJ represents an independent body under the Cabinet Office focusing on the risk of food. Even though it conducts food safety assessments for the MHLW, it is not a risk management institution, such as the MAFF, MHLW, or MOE. The FSCJ may seem smaller in terms of the number of its members compared to China, but it has several external panels and committees that support its tasks (ibid., 3).

In terms of scope of staff, China's NBC had in the year of its founding 64 members, most of whom are experts from the fields of agriculture, environment, and food safety (Kou et al. 2015, 2160). Japan's FSCJ main staff includes four full-time commissioners and functions as an intermediate between Scientific Panels and risk managers. Next to the Scientific Panels, which are supporting entities outside the FSCJ, Japan has an Advisory Committee and a secretariat both assisting with risk assessment (FSCJ 2015, 2). China's Standardization Committee has a similar supporting role, like Japan's panel, committee, and secretariat. It is tasked with R&D and safety management and oversees 40 additional testing institutions that conduct tests to maintain all committees and departments in GMO supervision (Kou et al. 2015, 2160).

According to Mabaya et al., the financial investments a country decides to allocate to the biotechnology sector changes over time and depends primarily on its placement of jurisdiction for fund allocation (2015, 581). While in China, the MOST is primarily involved in the allocation of funds and financial investments, Japan's promotion of S&T lies in the jurisdiction of its CSTP, not a ministry but a council in the Cabinet Office. Even though seven ministries are involved in the S&T administration, the Minister of State for S&T Policy and the CSTP are the main entities that deliberate policies and forward them to the government to be formulated and decided upon (Cabinet Office, GOJ n.d.a.). The CSTP was reorganized to the CSTI in 2014, adding innovation as one of its pillars (Cabinet Office, GOJ 2016, 5). Based on Mabaya et al.'s research, a higher number of involved ministries would slow down the regulatory process and lead to higher expenses (2015, 581). In both China and Japan's case, the main involved entities are kept at a minimum, and both have S&T as the main subject on their agenda.

China started to publicly support R&D in agri-biotech in the early 1980s (Falkner 2006, 476). The budget and funds in the 1990s were initially invested in basic research and regulations to formulate primary policies and motivate the advancement of biotechnology (Gilmour et al. 2015, 75). Japan had a head start on China by initiating political discussions of GM biotechnology in the 1970s and forming its regulations by the end of the decade. These preparations enabled the technology's adoption by the 1980s with applications in medicine, industry, and agriculture (Shineha and Kato 2009, 142). Both East Asian countries initiated their approach towards advancement in biotechnology by investing in basic scientific research and public education during the first years, once having identified biotechnology as one of their key sectors. This approach is represented in China's 973 Program and its successive Five-Year Plans since the 1990s as well as Japan's first Basic Plan in 1996.

Throughout the 1990s, China established several ministerial-level fund strategies to encourage biotechnology development, additionally to the existing national plans and programs. The MOST was a driving force behind projects promoting basic research and commercialization of GM plants (Huang and Wang 2002, 125). The programs that were adopted, such as the 863 Program in the 1980s and the 973 Program in the 1990s, collected a substantial amount of funds and were essential for the expansion of China's technological capacity (Gilmour et al. 2015, 75). The recent regulations for GM biotechnology are based on the State Council's plans from 2001 (ibid., 74). China's continuous financial support over the last two decades is stated in China's Five-Year Plans since the 11^{th} Five-Year Plan in 2006 (KPMG 2016, 15).

Similar to China's Five-Year Plans are Japan's S&T Basic Plans. Its First Basic Plan for fiscal 1996-2000 called for aggressive promotion of R&D and basic research. Japan's First Basic Plan reflected the global hype for biotechnology and crucial investments into basic research at first, which is the same approach China has adopted at the early stage of biotechnology development. Japan additionally invested in the fostering of young researchers with its "10 000 researchers-support-plan" (Cabinet Office, GOJ 2001, 16). Investments like this are one reason why Japan traditionally has a strong base of researchers. S&T policies encouraged their flourishing, especially during the First and Second Basic Plan, which started in the 1990s and reached throughout the early 2000s. China's counterpart measure would be the 863 Program, the first national program to inspire thousands of young scientists' interests in S&T (MOST n.d.a.).

Between 2006-2010 both countries continued to be involved with the advancement of S&T; however, Japan's earlier unobstructed support from the government and population were compromised by increasing civil resistance since the 1990s. This opposition decelerated Japan's initial vigorous promotion of R&D and induced the government to emphasize bioethical issues and resources to mitigate civic concerns (Cabinet Office, GOJ 2006, 3). Meanwhile, China adopted its 11th Five Year Plan and continued its unwavering support in the form of rising public funds and investments into R&D of S&T (Gilmour et al. 2015, 76). Despite the beforementioned domestic issues, Japan's investments showed a similar trajectory as China's with increasing financial investment in R&D. Currently, the biggest national project for biotechnology in Japan is embedded in the SIP, which is a promotion program financially supporting innovation, including agri-biotech (Cabinet Office, GOJ 2017b). In China, financial support for agri-biotech's application can be detected in biotech-friendly regulations towards its R&D and subsidy payments for grain, quality seeds and agricultural machinery. These investments should encourage farmers to enhance grain production through the application of biotechnology products (Jiao et al. 2018, 758).

The amount of financial investments influences the sufficient availability of professional staff and the needed financial resources for advanced technological equipment. Since the number of expenses of China and Japan from each of their statistical yearbooks are provided in their own currency only, the data have been collected in the form of the GERD in current PPP$ and R&D expenditure as a percentage of GDP to achieve consistency and enable an international comparative analysis. The table below shows the numbers of both the beforementioned indicators from each country.

Year	GERD (in current million PPP$)[9]		R&D expenditure (% of GDP)[10]	
	China	Japan	China	Japan
1996	14.20	82.97	0.56	2.69
1998	19.75	91.00	0.65	2.87
2000	33.08	98.92	0.89	2.91
2002	48.11	108.17	1.06	3.01
2004	70.16	117.52	1.22	3.03
2006	105.56	138.74	1,37	3.28
2008	146.11	148.72	1,45	3.34
2010	213.49	140.62	1,71	3.14
2012	292.20	152.33	1.91	3.21
2014	370.61	164.66	2.02	3.40
2016	451.41	168.64	2.11	3.14
2017	495.98	175.84	2.13	3.20

Table 11: Comparative table of China and Japan's GERD and R&D expenditures

[9] Collected from the UIS (2019c) in million PPP$ and rounded up to two decimals
[10] Collected from the World Bank (2019a) rounded up to two decimals

The table shows the data from China and Japan from 1996 to 2017 and reflects each nation's commitment and implementation of announced measures in their national plans for S&T. By setting national targets for R&D spending as a share of GDP, several countries have tried to stimulate investment in the S&T sector. Japan is one of the countries that adopted this method and achieved its target of 3 percent of GDP for R&D expenditure successfully by 2002 with merely two years of delay (World Bank 2019a). Japan's first two basic plans covered a time that was characterized by economic stagnation. However, despite the critical circumstances, the government kept increasing its expenditure in S&T to promote basic research and develop a competitive R&D environment. By the time the Third Basic Plan was formulated for 2006-2010, the Japanese economy had recovered, and the percentage of R&D expenditure to GDP was expected to be "raised up to at least the same level as in the United States and major European countries," which Japan fulfilled on its part. By 2002 Japan had already reached the three-percent mark for the first time, leaving the US behind with its 2.55 percent.

China stayed its upward trajectory true, but remained far behind with its 1.71 percent in 2010 and reached the two-percent-mark not before 2014. According to the UIS's latest available data, in 2017, the top investors in the R&D sector are Israel with 4.58 percent, South Korea with 4.55 percent, and Sweden 3.31 percent. Japan with 3.20 percent, Austria with 3.16 percent, and Germany with 3.04 percent are among the few countries that have also reached the 3-percent mark of the R&D expenditure as a proportion of GDP. The EU has set its target to raise overall R&D investment to 3 percent of GDP by 2020, which in 2019 only Sweden, Germany, and Austria have reached (UIS 2019c).

For human resources, both the FTE and the HC of R&D personnel were determined for the two East Asian country cases, since the OECD recommended both for the measurement of R&D personnel. While for international comparison, the FTE is considered to be the main tool to measure R&D personnel, the HC is recommended for the exploratory purpose to determine the characteristics of R&D personnel. Both indicators were used based on the OECD's recommendation to balance out over- and underestimations of the R&D personnel and provide complementary information (2015, 165). The comparative table below encompasses both the FTE as well as the HC of R&D personnel of each country case.

Year	FTE of R&D personnel[11]		Total R&D personnel (HC in million)	
	China	Japan	China[12]	Japan[13]
1996	804 000	891 783	2.90	n.a.
1998	755 200	925 569	2.81	n.a.
2000	922 131	896 847	3.22	1.05
2002	1 035 197	859 453	3.22	1.03
2004	1 152 617	872 752	3.48	1.10
2006	1 502 472	910 375	4.13	1.15
2008	1 965 357	882 739	4.97	1.16
2010	2 553 829	877.928	3.54	1.16
2012	3 246 840	851 132	4.62	1.13
2014	3 710 580	895 285	5.35	1.19
2016	3 878 057	872 340	5.83	1.18
2017	4 033 597	890 749	6.21	1.20

Table 12: Comparative table between China and Japan's FTE of R&D personnel and total R&D personnel in HC

Here again, a steep rise of FTE of R&D personnel from China can be observed, from lagging behind Japan in the 1990s to catching up rapidly. It surpassed the one million mark in the early 2000s and continued to raise its FTE to many times the amount of Japan's in the following years. Japan's HC shows a rather subtle but still visible rise of personnel invested in R&D as well. It is worth noting that until the early 2000s, Japan's FTEs used to be even higher than China's, with only one-third of China's HCs. This also reflects Japan's "technology-first approach" from the First Basic Plan. In the 1990s, Japan was one of the countries with the highest number of researchers, subsidized by the "10 000 researchers-support-plan." However, the the early 2000s are characterized by a decline, which Japan's Second Basic Plan explained as a side effect of the beforementioned underdeveloped mobility of human resources. Even though this support increased the numbers of young people embracing the R&D fields, it did not consider the importance of the relationship between young researchers and research advisors, leaving many novice researchers unsupervised with job hunting (Cabinet Office, GOJ 2001, 16).

[11] Collected from the UIS (2019b)
[12] Collected from the NBSC (1999) for 1996-1998 and the World Bank (2019b) for 2000-2017, rounded up to two decimals
[13] Collected from the Statistics Bureau, MIC (2011) for 1995-2000 and the World Bank (2019b) for 2002-2017, rounded up to two decimals

Overall it can be concluded for the financial resources that both countries have been striving to expand their S&T sector by increasing their investments annually. Rising expenditure tends to lead to increasing personnel, although it is not strictly the rule, and exceptions can be detected. The incorporation of specific endorsed technologies, such as biotechnology, into each of their national plans, played an important role in their investment in financial and human resources, considering the measures taken to increase their funding. China's R&D expenditure as a percentage of GDP has never dropped according to the World Bank (2019a); however, its total R&D personnel did not always reflect the same upward trajectory. With the 863 Program and 973 Program, China's S&T sector received major investments in R&D early from the 1980s.

Japan's improvements in the same sector seem to be less steep in numbers since it reached a high level of standards in the 1990s already, as evidenced by its R&D expenditure at 2.69 percent of GDP in 1996 when China was still at 0.56 percent in the same year. Japan's number of persons engaged in R&D has always been only a fraction of China's, but the country still managed not only to keep up with China but also to trump its numbers of FTE of R&D personnel in the initial phase. In the early 2000s, a policy update on biotechnology's general support as the national priority area on S&T was launched, and governmental funding agencies restructured. The MAFF traditionally supported the research of crops genome and promoted GM crops (Watanabe et al. 2005, 516). However, there has been no major venture actively funding Japanese plant biotechnology in recent years.

Criteria	Indicators	China
• Advancement of key industry technologies • Human resources • Financial resources	– Progress in agricultural S&T – Seed sector development – Supporting policies for innovations – Existence of NBC – Existence of other technical entities and staff – FTE of R&D personnel – Total R&D personnel (in HC) – Public initiatives for financial investments in S&T – Expenditure for R&D in GERD in current PPP$ – Proportion of R&D expenses to GDP (in %)	→ Leading nation in R&D of rapeseed, hybrid rice, food legume → Advanced seed handling capacity and field management → Innovation supported by MOA, MOH, AQSIQ and State Council → R&D focus of GM crops for national food security → Existent NBC with 64 members → State Commission, public test institutions → 4.03 million persons in 2017 → 6.21 million HCs in 2017 → 863 Program, 973 Program, 10^{th} – 12^{th} Five Year Plans → 495.98 million PPP$ in 2017 → 2.13% of GDP in 2017
Criteria	Indicators	Japan
• Advancement in key industry technologies • Human resources • Financial investments	– Progress in agricultural S&T – Seed sector development – Supporting policies for innovations – Existence of NBC – Other technical entities – FTE of R&D personnel – Total R&D personnel (in HC) – Public initiatives for financial investments in S&T – Expenditure for R&D in GERD in current PPP$ – Proportion of R&D expenses to GDP (in %)	→ R&D in cost-saving crop production and gene-editing methods → R&D of high-yielding seeds for stable supply, seed supply center → Innovation supported by CSTI → Active promotion of innovation but with case-by-case approach → Existent FSCJ with 4 commissioners → Scientific Panels, Advisory Committee, secretariat → 0.89 million in 2017 → 1.20 million in 2017 → S&T Basic Plans, "Next Generation Agriculture" in SIP → 175.84 million PPP$ in 2017 → 3.20% of GDP in 2017

Table 13: Results of comparative assessment of technical capacity in China and Japan

5.1.5. Comparative assessment of food security crises of China and Japan

Even though both China and Japan are not classified by the IPC as countries with acute food insecurity of level IPC 3, there is no country that remains unaffected by global food crises (Essex 2014, 268). The import of crops plays a crucial role in preventing food insecurities by ensuring the availability and accessibility to food through acceptable prices. Even though China and Japan are not in the immediate state of food insecurity or a crisis, both have escaped this fate on account of the presence of GM crops. Despite both countries' decreasing food self-sufficiency over the years, each government still has the capacity to ensure food availability by increasing import (Xie et al. 2017, 349). With the trade of food grains comes GM crops inevitably, since most of the major imported food and feed crops, which both are massively importing to cover their lack of domestic outputs, are produced with the help of GM biotechnology. Both countries belong to the largest importers of agricultural food and feed products (Zheng et al. 2017, 397; Nakai et al. 2015, 930).

Neither China nor Japan have found themselves in recent years under severe threats to agriculture with the capacity to cause drastic turns of perceptions among farmers, consumers and policymakers like Mabaya et al. illustrated in their research with Africa (2015, 587). The main environmental challenges in Japan are caused by unstable weather conditions; especially frost can cause severe losses for rice crops (Nakai et al. 2015, 930; ISAAA 2016, 89). Droughts, pests, and diseases are agricultural threats in China. The adoption of Bt cotton resistant towards bollworm outbreaks is one of the initiatives encouraged by Chinese policymakers and adopted by Chinese farmers (Xin and Stone 2008, 363). Under these circumstances, especially small farmers benefit from GM cotton adoption due to reductions of pesticides and the resulting decreasing health and environmental effects. There are also financial benefits due to higher yields resulting from more resilient crops and cost savings through the reduced need for agricultural chemicals (Newell 2008, 121).

However, both countries have food security concerns based on similar problems concerning natural resources. A common challenge of both countries is the struggle with limited resources. Both nations' arable lands are reaching their maximum capacity with China's situation is less dire than Japan's. While Japan's arable and permanent cultivated land are both decreasing rapidly, China seems to still have enough arable land left to be converted to cultivated land and has been continuously adding up the size of land under permanent crops (FAO 2019a; ibid. 2019b). Nevertheless, China's natural resources are also limited and thus raising the existing challenges as well, especially considering its growing industrialization and urbanization (Kou et al. 2015 2163). Next to natural resources, decreasing human resources in rural areas represents another challenge for both countries. Unlike China, whose rural population is gradually shrinking, especially with young people heading towards metropoles (Liao 2010, 106; Yan et al. 2015, 375), Japan's rural population is both aging and rapidly declining in its numbers (FAO 2019a).

In terms of dealing with food security concerns through the adoption of GM biotechnology, it is not enough to only provide the technology as a tool. Corresponding knowledge and training of the newly offered technologies are just as crucial for farmers to implement them correctly and reach maximal benefits (Chen et al. 2013, 22). The absence of proper education for both farmers and the general population is a serious issue affecting the adoption of GM crops in both countries. In Japan, not all farmers have access to adequate information about all crop planting options, including GM biotechnology as a cultivation tool that is not regularly promoted (Watanabe et al. 2005, 519). Especially farmers require education and access to the latest agricultural update in order to learn about their correct treatments and reach the full potential of new crop varieties. In China this is still not possible for many farmers due to lack of extended services to some rural areas (Jiao et al. 2018, 761).

However, overall Chinese farmers are moving towards accepting GM food crops adoption due to governmental endorsement. In China, the development of GMOs in agriculture grew in an overall supportive policy environment where biotechnology's advancement is encouraged. This positive environment for the development and adoption of agri-biotech is the result of cooperation and communication between the scientific and political communities (Cao 2019, 55). Policymakers in Japan are much more cautious and susceptible to civic movements. Especially Mabaya et al.'s prediction of elected politicians being under a strong influence of public opinion has fulfilled its prophecy in the case of Japan (2015, 585). Japanese farmers are generally not as opposed to GM crops as their consumers, but suffer under overregulation of GM biotechnology, applied by policymakers, who attempt to comply with consumers' demands (Nishizawa and Renn 2005, 45; Yamaguchi and Reiher 2017, 5).

Criteria	Indicators	China
• Natural threats to agriculture	– Resource limitations – Environmental challenges	→ Limited arable land and water resources → Droughts, pests and diseases affecting crops
• Perception during challenges	– Farmers' perception – Policymakers' perception	→ Open towards the GM crop adoption, informed about agronomic benefits → Supportive towards adoption of GM crops
• Benefits of GM crop adoption	– Farmers' benefits – Policymakers' benefits	→ Higher yields, health and environmental benefits → Improvement of nation's food self-sufficiency and economy via trade
• Barriers to GM crop adoption	– Farmers' challenges – Policymakers' challenges	→ Lack of training and knowledge → Type of small farmer's ownership of scattered land plots
Criteria	**Indicators**	**Japan**
• Natural threats to agriculture	– Resource limitations – Environmental challenges	→ Decreasing arable land → Unfavorable weather conditions including frost and droughts
• Perception during challenges	– Farmers' perception – Policymakers' perception	→ Many open towards GM crop adoption, especially during low yield → Susceptible to public opinion
• Benefits of GM crop adoption	– Farmers' benefits – Policymakers' benefits	→ Potential of higher yields, resistance against unstable weather → Potential raise of nation's food self-sufficiency
• Barriers to GM crop adoption	– Farmers' adoption barriers – Policymakers' adoption barriers	→ Overregulation due to consumer resistance → Consumer resistance

Table 14: Results of comparative assessment of food security crises in China and Japan

5.1.6. Comparative assessment of the role of media and activism in China and Japan

Mabaya et al. mentioned in their research the phenomenon of the chain reaction between media, public opinion, politicians, and policy. Media respond to sensationalism, which can sway public opinion, that again can influence politicians, whose decisions tend to be driven by public opinion than science. Strong opinions can lead to activism at its hike, which has an even more focused influence on a specific public issue that can put politicians under pressure. Policies and statements provided under these circumstances turn out to be biased, unless countermeasures are taken in time, such as public awareness programs (2015, 585). The role of media is crucial in supporting or discouraging stakeholders' acceptance of GM biotechnology and its food products since it remains the primary source of information, especially for consumers. Various types of media, such as TV, radio, print media and internet, are the main media tools used to both convey and gain knowledge about GM products (Vigani and Olper 2013, 37).

According to Han et al., primary target groups of Chinese media are consumers and farmers. This can be attributed to the country's publicly owned media with firm state control, which demands Chinese media to fulfill governmental functions (Rohrhofer 2014, 182). Communication with the population, including consumers and farmers, and the representation of state policies belong to its tasks, although it also has to manage commercial competitiveness by attracting viewers and advertisers (ibid., 179). The primary target group of Japanese media is the consumers which can be traced back to Japan's media system. Unlike China, Japan has a commerce-oriented media with state control at the middle level only. Therefore, its media has more room with less social responsibility (Rohrhofer 2014, 182). Even though Japan officially has mixed ownership, all Japanese media businesses are privately owned, with the NHK being the only exception (ibid., 175). High competition caused increasing media coverage of food scandals that followed anti-GMOs movements and influenced consumers' preferences (Reiher and Yamaguchi 2017, 5). Mabaya et al. prophesized that "popular media outlets publish what sells." Since popular media outlets are not bound by the same rules as scientists, there is much space available for both legitimate concerns as well as trending unverified dangers of GMOs (2015, 586). McCluskey and Swinnen have warned from the bigger impact negative information can have than positive ones (2011, 626). These have fueled in both countries anti-GMO activities, which led to strict regulations.

While Chinese farmers tend to have a positive approach towards GM crops by witnessing their peers' benefits and sharing each other's experiences, Chinese consumers' views on GM crops are compared to the farmers more ambiguous. However, due to media influence and their high trust in scientists and policymakers, consumer's acceptance of GM crops in China are still relatively high compared to other countries. Since the information disseminated through the main media channels are in line with national policy, which is currently in favor of the R&D of GM biotechnology and the use of GM crops, consumers' trust in GM foods is continuously growing (Han et al. 2015, 4). On the other hand, Japanese consumers have been expressing unsafe feelings towards GM foods since the beginning of GM crop import into their country (Komoto et al. 2016, e23; Nishizawa and Renn 2006, 45). Their two main concerns are food safety and environmental risks, for which, however, they are being criticized by scholars and scientists due to their lack of knowledge concerning the country's status of food security and general biology. The best countermeasures against these fears are public awareness campaigns and education about basic biology (Watanabe et al. 2005, 519).

Unlike Japanese consumers, Japanese farmers used to be more open towards the idea of cultivating GM crops. However, due to strong anti-GMO movements from consumers and the fear of stigmatized food products that would not sell, the farmers soon dropped the already planned project again (Masanuga 2013; Nishizawa and Renn 2006, 45). Chinese farmers were similarly open towards the adoption of GM crops, although unlike Japanese farmers, they experienced less resistance from the population in general. However, it has to be noted that China primarily cultivates GM cotton and not GM food crops. Chinese farmers who cultivate GM cotton seem to be overall satisfied with the economic advantages that came along its adoption and expand the benefits by sharing their experiences with their community (Han et al. 2015, 1). Most of all, the adoption of GM crops and the advancement of biotechnology is acknowledged and supported by the Chinese government (Cao 2019, 49; MOST n.d.a.; ISAAA 2017, 44), unlike the Japanese government with decreasing support and absence of open advocacy. Especially many local governments have been effectively convinced by consumers, who bypassed central government to reach their cause, and advocated for strict rules for the use of GMOs (Shineha and Kato 2009, 147). Japan seems to be a contrary case to Vigani and Olper's prediction that "in agricultural and food markets, government policies are biased in favor of […] farmers' interests in rich countries" (2013, 37).

Criteria	Indicators	China
• Domestic media structure	– Control of media – Function of media – Main target groups	→ State-controlled → Political and commercial purpose → Both farmers and consumers targeted
• Awareness and acceptance	– Awareness and acceptance of consumers – Awareness and acceptance of farmers	→ Existent consumer awareness and consumers' acceptance → Existent farmers' awareness and farmers' acceptance
• Debates and activism	– Source of opposition – Anti-GMO activities	→ Originated from food safety scandals and consumers → Driven by ideological and conspiratorial concerns → Greenpeace, Utopia
Criteria	**Indicators**	**Japan**
• Domestic media structure	– Control of media – Function of media – Main target groups	→ State- and private-controlled → Commercial and public responsibility → Mainly consumers targeted
• Awareness and acceptance	– Awareness and acceptance of consumers – Awareness and acceptance of farmers	→ Traditionally low awareness and rising acceptance → Existent awareness and rising acceptance
• Debates and activism	– Source of opposition – Anti-GMO activities	→ Emerged out of consumer groups → Food safety, environmental impact, multinational corporations' control → Strong civil society network since the 1990s

Table 15: Results of comparative assessment of role of media and activism in China and Japan

5.2. Comparative assessment of influencing regulatory components during the adoption in China and Japan

5.2.1. Comparative assessment of the approval process and risk assessment in China and Japan

In the past years, China has been trying to remove inconsistencies that occur in its regulations for biotechnology, especially concerning issues in the biosafety and approval process. Unlike China, the Japanese regulatory system for GM biotechnology and its products is well-structured and has a clear allocation of regulatory tasks. Japan applies a pragmatic approach towards GM biotechnology and GM crops (Wang 2016), unlike China whose regulatory framework is viewed as too complicated and deliberately time-consuming, which has been interpreted to have the purpose of encouraging domestic biotechnology advancement and production (Ma et al. 2017). While Japanese regulatory authorities are divided into different units and can easily be assembled depending on the product running through the approval process, the Chinese counterpart has several institutions with overlapping duties. Even though Japanese approval regulations can be considered as complex and costly as well, unlike China's system, they still remain "predictable and functional" (Sato 2010). Both countries have been trying to continuously upgrade the efficiency of their own regulatory frameworks. While the chances for both countries to lift the requirements of tests for all crops are unrealistic, Japan has already started to make exceptions for GM food crops, with corn among them, that do not have wild relative on domestic soil (Sato 2016).

In terms of AA, the two East Asian countries share similarities in the causes of the situation. Both China and Japan apply the zero-tolerance policy for unapproved events, which is the most stringent regulation for the approval process. It requires no trace of unapproved GM crops and immediate withdrawal from the market in case of occurrence (Ma et al. 2017, 462). According to Kalaitzandonakes et al., trade between asynchronous countries abiding by the zero-tolerance policy are less common, since both importing and exporting countries would try to avoid risks that are accompanied by strict regulations (2014, 147). In this regard, both China and Japan are perceived as "risky export markets." However, in recent years China's agri-biotech market seems to be more difficult to access due to the increasingly complex approval process and the requirement of approval renewals, which Japan has not embraced yet. It is worth noting that China's current policy for trade with GMOs requires only domestic approval of GM crops. This means that export shipments with Chinese commodities and processed foods can contain LLP of GM events. However, for its own GM food and feed imports, China has implemented the case-by-case policy (Huang and Yang 2014, 31). Japan, on the other hand, has stayed overall true to its zero-tolerance policy and does not accept LLP of unapproved biotech crops of any kind, which makes the absence of LLP crucial for smooth agricultural trade with Japan (Sato 2010).

China has a mandatory risk assessment regulation, which includes field assessments and their reviews both before and after lab tests are conducted. However, its inspection and quarantine systems for risk assessment have become increasingly complicated due to inconsistent regulations in regards to testing sensitivities and the threshold for positive results for their labs (Ma et al. 2017, 462). Japan, on the other hand, is marked with the exact opposite characteristics of its risk assessment, which has a relatively transparent structure. Each new GMO can be categorized according to its field of usage, which again determines which department will be responsible for the evaluation of its risk assessment. The tests are conducted by the FSCJ, a national committee that is supported by an Advisory Committees and Scientific Panels (FSCJ 2015, 3).

Compared with the EU's precautionary principle and the American substantial equivalence, both Japan and China have steered a middle course between these two polar opposites for a long time. However, when comparing specifically the two East Asian countries with each other, it can be detected that, while China is leaning increasingly closer towards the precautionary principle, Japan is comparatively more efficient with its approvals similar to North American nations. While Japan is not as fast as the US with its approval process, it remains a close second in both the quantity and speed of approvals (Wang 2016). Nevertheless, in the years following the mass approvals until the early 2000s, Japan started to expand the decision-making platform of its approval process beyond the purely scientific base in order to reach public assurance concerning food safety. However, due to Japan's limited local resources and dependency on food imports, public assurance will not always remain a priority compared with food availability.

China has been increasingly leaning towards the EU's cautious way of regulation. However, unlike Japan, China's tendency towards the precautionary principle finds its origin primarily in economic reasons, such as the protection of domestic producers and the promotion of domestic biotechnology enterprises (Newell 2008, 120). Even though China has been increasingly tightening its rules regarding the approval process, the implementation of these updated regulations is still characterized by uncertainties (Wang 2016). One of the criticisms at China's approval process is that it is "too fragmented and incoherent" and "dispersed across too many departments," whose roles in the process are not clearly defined (Newel 2008, 126).

Criteria	Indicators	China
• Type of main approach	– Application of precautionary principle – Application of substantial equivalence	→ Application of precautionary principle
• Scope of approval execution	– Involved entities in approval process – Complexity for new GM crops approvals	→ Primary MOA solely, 7 governmental agencies led by State Council → Strict and complex approval process
• Existence of AA	– Policy for unapproved GM crops – Requirement of approval renewals	→ Application of zero tolerance policy → Requirement of approval renewals every 3 years
• Stage of risk assessment	– Mandatory, proposing or not existent – Focus and extensiveness of risk assessments	→ Mandatory risk assessment → Lab tests conducted by NBC, reviewed by MOA/OBA
Criteria	**Indicators**	**Japan**
• Type of main approach	– Application of precautionary principle – Application of substantial equivalence	→ Application of precautionary principle
• Scope of approval execution	– Involved entities in approval process – Complexity for new GM crops approvals	→ 4 ministries involved: MAFF, MHLW, MOE, MEXT → Pragmatic approach
• Existence of AA	– Policy for unapproved GM crops – Requirement of approval renewals	→ Application of zero tolerance policy → No requirement of approval renewal
• Stage of risk assessment	– Mandatory, proposing or not existent – Focus and extensiveness of risk assessments	→ Mandatory risk assessment → Lab tests conducted by FSCJ for all GMOs for R&D, food and feed

Table 16: Results of comparative assessment of approval process and risk assessment in China and Japan

5.2.2. Comparative assessment of labeling and traceability in China and Japan

On the international level, there is a large heterogeneity among labeling regimes. The differences among some countries are higher than others. Both China and Japan belong to the latter and adopted mandatory labeling regulations next to the EU and other countries, such as Australia or Brazil. However, even among mandatory adopters, some added voluntary guidelines specifically for the labeling of non-GM food, such as Japan and the EU. These cases are also referred to as "mixed mandatory-voluntary system." They can predominantly be detected in those countries with a mandatory labeling system in which consumers are both capable and willing to pay more money in order to avoid GM ingredients entirely (Gruère and Rao 2007, 52). This phenomenon can be observed especially in Japan. While Japanese consumers are willing to invest a premium in order to gain non-GM food (ibid., 54), many Chinese consumers are primarily concerned with the price of their food (Han et al. 2015, 8). It turned out that even within the regime of mandatory labeling systems, there is a scope of different varieties that primarily differ from each other in their coverage and threshold level.

Throughout the empirical research, the criteria of threshold level for labeling can be distinguished again in several types of identification thresholds. A GM food label, therefore, can have a positive label and a negative label. If the GM materials that are mixed with non-GM ingredients exceed the threshold level of the allowed amount, then the positive label has to be applied to the product within a mandatory labeling system. If the amount of GM material is lower than the threshold, then no labeling is required. A negative label or GM-free label can be applied if the product does not contain any GM trait, and adopting country wishes to do so. Currently, China still has not adopted a specific percentage threshold to properly execute this regulatory factor like other fellow countries that also use a mandatory labeling system. Instead, it uses a list of GM food commodities that require strict labeling (Zhang 2015, 255).

In contrast, Japan has a clear labeling threshold established at 5 percent, implying that the level for non-GM components in the final product should not exceed that percentage. Kamogawa defines Japan's labeling as a "mandatory and positive labeling regulation" with "voluntary and negative labeling on GM food" (2018). This indicates mandatory labeling for all food products that contain GM components above the threshold and voluntary labeling for non-GM foods. While Japan's approach may seem stricter due to its precise labeling threshold setting, it is actually the Chinese labeling list that is more elaborate to execute by including not only single food commodities but also their derivatives. This is a process that also involves the regulatory factors of labeling target and traceability (Gruère 2007, 52). Therefore, unlike China's rigid list with specific foods and their derivatives, the agreed upon threshold still provides Japan enough margin to maneuver food trade of a wider range of imported goods that cannot be covered by domestic production.

Next to the labeling threshold, Vigani and Olper's research separated labeling regimes in voluntary and mandatory systems based on the regulation's target as well, which is either aimed at the finished product or the production process (Gruère 2007, 52; Vigani and Olper 2013, 34). Here, China shares the same approach as the EU and Brazil and focuses, in terms of labeling target, on the GM technology used in the production process. On the contrary, the Japanese mandatory labeling system targets the presence of GM ingredients in the final product, similar to Australia and New Zealand. China is on the one end of the spectrum with its process-based system, which is the most stringent approach in terms of labeling target and matches its general approach of its labeling regulation. In the meanwhile, Japan is on the other end of the spectrum with its product-based system, which is sufficient to both satisfy its consumers, by targeting the end product itself, as well as flexible enough to provide room to adopt various GM foods (Gruère and Rao 2007, 52).

In terms of traceability, the authors distinguish between the preservation of identity and a system of traceability. A functioning system of traceability is much more complex than the provision of a product's IP and, therefore, also comes along with higher costs for its compliance. Exporting countries tend not to have any traceability requirements for GM ingredients, such as Argentina and India (Vigani et al. 2012, 420). China's traceability system is limited to specific products only reflecting its labeling regime (Yang 2003, 106). On the other hand, traceability's importance seems to be much higher to importing countries. The EU and Japan, for example, both have mandatory traceability regulations. Especially Japan considers IP handling to be crucial and a key component to enable a traceable system (Japan Food Industry Center 2002, 5). However, within the comparative assessment, it has to be concluded that China, with its current labeling regulations, is in a much direr need of a traceable system than Japan. Based alone on China's more rigorous approaches regarding both the labeling threshold and the labeling target, the application of a traceability system is vital.

Criteria	Indicators	China
• Regime of labeling	– Mandatory basis – Voluntary basis	→ Mandatory labeling regime
• Threshold level for labeling	– Without or with threshold higher than 1% – Threshold equal or lower than 1%	→ Without labeling threshold
• Labeling target	– GM presence in finished product – GM technology as production process	→ Process-targeted labeling system
• Traceability of GM products	– Mandatory GMO traceability – Proposed GMO traceability – Absence of GMO traceability	→ Mandatory traceability only for specific products
Criteria	Indicators	Japan
• Regime of labeling	– Mandatory basis – Voluntary basis	→ Mandatory + voluntary labeling regime
• Threshold level for labeling	– Without or with threshold higher than 1% – Threshold equal or lower than 1%	→ Labeling threshold at 5%
• Labeling target	– GM presence in finished product – GM technology as production process	→ Product-targeted labeling system
• Traceability of GM products	– Mandatory GMO traceability – Proposed GMO traceability – Absence of GMO traceability	→ Mandatory traceability with IP handling

Table 17: Results of comparative assessment of labeling and traceability of China and Japan

5.2.3. Comparative assessment of coexistence in China and Japan

Coexistence has the purpose of offering consumers as well as farmers the possibility to choose between foods produced from organic, traditional, or GM farming systems (Vigani and Olper 2013, 34). According to Azadi et al., coexistence strategies can be easier implemented if labeling and traceability regulations are in place. These three regulatory aspects are interconnected and can influence each other's success. The authors show that countries with an elaborate labeling system and a traceability system tend to be more successful in enabling coexistence. While labeling and traceability are important tools to support the facilitation of coexistence, consistent traceability and a reliable coexistence again can enforce consumers' trust in the labeling of GM foods. A reliable coexistence approach that contains a consistent traceability system would be able to improve the commercialization of GM products as well (2017, 3).

Organic farming is "codified and regulated within a legal framework," which can originate from organic principles, such as the Codex Alimentarius (FAO/WHO 2007) or the International Federation of Organic Movements (IFOAM) (Oelofse et al. 2011). Functioning labeling and traceability are preferable regulations to enable coexistence, especially for high maintenance farming systems like organic farming. Both China and Japan have a functioning labeling system as well as a traceability system, enabling freedom of choice for customers and producers. However, unlike Japan, with its already existing guidelines for coexistence, China currently does not have any coexistence policies even though it technically allows GM crops production upon authorization. With the Hyogo guidelines and the Kyoto guidelines, Japan already has coexistence guidelines since 2006 for production and commercialization encompassing farmers' and consumers' concerns (Sato 2016).

Nevertheless, it is China, out of these two East Asian countries, that is currently cultivating GM crops even without official coexistence guidelines. Japan, on the other hand, seems to have better regulatory requirements with a more elaborate labeling system and a functioning traceability system. However, it has so far only planted GM blue rose and not cultivated any GM food plants (ISAAA 2016, 7). By contrast, China is currently planting GM cotton and GM papaya on large-scale while still being criticized for its inefficiency and politicized decision-making in terms of approval of commercial cultivation of food crops, especially when facing the advantages that come along GM crop adoption (Li et al. 2015, 839). In 2016, China claimed to aim for the GM crops of Bt corn and HT soybeans to be commercialized by 2020 (Hvistendahl 2017, 16). Therefore, coexistence measures in place would not only ease the two current existing conventional and organic farming systems but also improve the regulation of more upcoming large-scale GM crop cultivations. This is especially relevant considering China having passed biosafety evaluations for GM corn and GM soybean earlier this year (Gu and Patton 2020). Japan, on the other hand, currently only has two crop farming systems for the cultivation of organic and conventional crops and is currently not planting GM food crops. The cultivation of organic crops is especially challenging due to suboptimal climate conditions and limited arable land in Japan. Both conventional and organic farms in Japan are kept mostly small (FAO/ITC/CTA 2001).

China manages the coexistence of conventional and organic systems by using crop rotations between different crop varieties and farming systems. Apart from the beforementioned rotations between conventional and organic crops, China does not have any mandatory crop segregation measures for coexistence in place (Oelofse et al. 2011). Japan, on the other hand, has set more specific rules in this regard, including both administrative measures in the form of the beforementioned Kyoto and Hyogo guidelines, as well as technical measures, such as the buffer zones and minimum isolation distance in order to prevent cross-pollinating. The exact regulating standards vary from each crop variety, including their necessary equipment for isolation, monitoring (Kamogawa 2018). These turn coexistence into one of the costliest regulations for GM crops, which developing countries tend to forgo out of convenience and cost reductions.

Criteria	Indicators	China
• Availability of coexistence strategy	– Comprehensive guidelines – Not yet enforced guidelines – Absence of guidelines	→ No available coexistence guidelines
• Current coexistent farming systems	– Availability of organic crop farming – Availability of conventional crop farming – Availability of GM crop farming	→ Among the top-five countries with the largest organic crop area → Existing farming of conventional crops → Farming of GM cotton and GM papaya
• Crop segregation measures	– Technical crop segregation measures – Administrative crop segregation methods	→ Crop rotations → No official administrative crop segregation methods
Criteria	**Indicators**	**Japan**
• Availability of coexistence strategy	– Comprehensive guidelines – Not yet enforced guidelines – Absence of guidelines	→ Comprehensive guidelines in the form of Hyogo and Kyoto guidelines
• Current existing farming systems	– Availability of organic crop farming – Availability of conventional crop farming – Availability of GM crop farming	→ Limited organic crop farming → Decreasing conventional crop farming → No GM food crop farming for commercial use
• Crop segregation measures	– Technical crop segregation measures – Administrative crop segregation methods	→ Buffer zones, isolation distance → Administrative measures based on Hyogo and Kyoto guidelines

Table 18: Results of comparative assessment of coexistence of China and Japan

5.2.4. Comparative assessment of China and Japan's membership of international agreements

The Codex represents a collection of recommendations for its members, which means that their application is on a voluntary basis. The goal of the Codex is to help developing countries to strengthen their national food control systems (FAO/WHO 2018a). It remains relevant for both East Asian country cases considering the growing international food trade they are increasingly involved with. Increased globalization also shows its effect on the food trade through the caused heterogeneity of food control systems among the trading countries and thus complicates food safety. Even though currently 189 countries embraced the Codex Alimentarius with its international guidelines, including China and Japan (ibid. 2019a), there is still a wide range of varieties among the national adoptions of food safety regulations (Kwak 2014, 225). Nevertheless, international cooperation in the form of standardized safety regulations benefits all countries, with the Codex offering common ground to build each of their food safety systems on (ibid., 226). Unlike the Cartagena Protocol, which represents an international document, the Codex Alimentarius is a collection of many guidelines and regulatory texts. Both China and Japan made use of what the Codex can offer and established many of their food safety regulations in cooperation with the CAC.

One of the differences between the two East Asian country's participation in the Codex and its commission, the CAC, is the high discrepancy on available national legislative texts on the official platform. While China joined only in 1984, it currently has 348 national legislative texts in compliance with the Codex at the CAC, Japan's number remains at 12 texts, even though its membership dates back to its foundation in 1963. However, these numbers do not necessarily reflect how elaborate each country has adopted the recommended regulations but rather offer an insight into each country's approach to incorporate the Codex's guidelines into their system. While China issues in each document a very specific food safety regulation often addressed to its provinces individually, each of Japan's regulatory texts at the CAC is as elaborate as comprehensive, especially compared to some of the single-paged Chinese documents (FAO/WHO 2019b).

Another difference shows in each country's participation in the CAC's meetings for biotechnology-related issues. In the 2000s, Japan hosted almost annually meetings for the CAC, which abruptly ended when civic concerns kept rising at the same time (Yamaguchi and Suda, 2010, 396). While Japan seems to have shown signs of withdrawal from these meetings, China increased its involvement around the same time by taking over the annual meetings for food additives and pesticide residues since 2007, along with its rising interest in biotechnology (Ma et al. 2017, 460). Nevertheless, correlation does not prove causality. Japan’s withdrawal from active involvement in the CAC does not necessarily prove to be the reason for China’s rising involvement since Japan remains one of the leading East Asian nations within the CAC. In some aspects, China even seems to share Japan’s trajectory considering the increasing awareness of Chinese consumers and their growing resistance towards GM food, especially in the years leading to 2010 (Han et al. 2015, 4).

In regards to the Cartagena Protocol, China and Japan both executed the agreement in quick succession with Japan ratifying it first in 2003 and China following just two years later in 2005. Unlike the Codex that focuses more on economic smoothness and consumer health, the Protocol puts biodiversity on the front by ensuring safe transport and use of LMOs. Both countries implement most of the provided articles within the protocol, with the exception of some single instances. One example would be the submission of national biosafety regulations to the BCH, which is established by the Cartagena Protocol for the exchange of information. Japan is known to submit all of its biosafety laws and regulatory guidelines to the BCH (Somiya 2015), which is in line with the transparency the country is generally encouraging (Cabinet Office, GOJ 2016, 47). China, on the other hand, does so more reluctantly and only on a partial basis. However, regarding the transit of GMOs, it is China that has implemented regulations, while Japan has refrained from following suit (Jing 2015; Somiya 2015).

Biosafety frameworks developed in Asia tend to have dominant national ownership. Governments in Asia often make substantial investments to maintain the systems they have applied and allocate national budget to cover respective costs (Mohamed 2013, 313). The possibility of receiving an allocation of funds provides the respective national biosafety framework a degree of freedom and autonomy, like economic independence that can be offered to the member states through the fact that participation cost of membership is covered through the Protocol budget (Koester 2013, 169). In this regard, China’s biosafety system is financially more dependent on its government, which also affects the national biosafety system’s development and the implementation of the Protocol. Japan, on the other hand, enjoys more freedom of action through the available budgetary allocation of funds (Somiya 2015).

Criteria	Indicators	China
• Codex Alimentarius	– Signed – Ratified – Execution	→ n.a. → n.a. → joined CAC in 1984, 348 national legislative texts in compliance
• Cartagena Protocol on Biosafety	– Signed – Ratified – Execution	→ Signed in 2000 → Ratified in 2005 → Executed since 2005
Criteria	Indicators	Japan
• Codex Alimentarius	– Signed – Ratified – Execution	→ n.a. → n.a. → joined CAC in 1963, 12 national legislative texts in compliance
• Cartagena Protocol on Biosafety	– Signed – Ratified – Execution	→ n.a. → Ratified in 2003 → Executed since 2004

Table 19: Results of comparative assessment of China and Japan’s membership of international agreements

5.3. Relevance of results

The main objective of this thesis is to achieve a comparative analysis of China and Japan's approach towards GM crop adoption. In order to answer the research question, it was necessary to incorporate both political and socio-economic factors as well as regulatory elements that influence the adoption of GM crops. Therefore, an individual AF was compiled based on three studies of peer researchers in this field. GM biotechnology and its crop products were chosen among the available agricultural biotechnologies. By exploring and comparing the similarities and differences between GM crop adoption in China and Japan, a disclosure of East Asia's approaches towards agri-biotech, especially GM biotech, was expected to be achieved.

In the initial step, the crucial influencing factors for GM crop adoption were identified. This can be of interest to both domestic as well as international policymakers and traders. The first section covered political and socio-economic factors that can critically induce or prevent the adoption of GM crops. In terms of the jurisdiction of biosafety, China and Japan seem to have similar structures within their governments, with one decisive ministry heading all related issues, such as the MOA administering these in China and the MOE taking the lead in Japan (Gilmour et al. 2015; Sato 2016). Even though different ministries are guiding agri-biotech matters in each nation, both countries share similar pragmatic and scientific-oriented goals.

Despite China's current arable land capacity and governmental support, it has made no clear decision about the domestic cultivation of GM food crops for a long time. There is an argument that China would rather outsource the cultivation of land-intensive crops to other countries, currently being Brazil and the US, in order to protect the fertility of its own farmland (Anderson and Strutt 2014, 50). Therefore, China will most likely carefully weigh out its options and remain selective towards its choices for GM food crop commercialization. Earlier this year, China has passed biosafety evaluations for GM corn and soybean, which is considered a crucial move towards the commercialization of these two GM crops (Gu and Patton 2020).

GM crop cultivation in Japan had traditionally proven to be a challenging feat with several failed attempts. While its farmers are similarly open towards the idea of GM crop cultivation, they are under more pressure than their Chinese counterparts due to strong consumer opposition and have to consider the potential stigmatization of the food they are producing. Even though GM crops' yields would be higher, it still might not raise their revenues if Japanese consumers are not willing to purchase them (Nishizawa and Renn 2006, 45). The importance and lack of sufficient training and education for farmers are relevant to both countries. Especially in China, where farmers are already cultivating GM cotton, this deficit requires an instant solution, since the adoption of GM crops cannot fulfill its maximum of benefit without sufficient knowledge (Jiao et al. 2018, 761).

One of the reasons for Chinese farmers' willingness has its roots in its supportive government and leading politicians who publicly advocate the GM biotechnology and GM crops. The Chinese leadership identified GM biotechnology as a primary tool in the challenge of achieving food security through sustainable development (Cao 2019, 60). Japanese politicians adopted a more cautious approach and tended to be more susceptible to civic opinions. Even though there have been a few strong supporters among past Japanese ministers, who openly advocated for the advancement of biotechnology, most of them were more guarded due to strong Japanese consumer movements. In this regard, Japanese media had played a crucial role by providing popular food scares among its consumers (Reiher and Yamaguchi 2017, 5).

By learning from past mistakes and shortcomings, it becomes possible to prepare or even avoid challenges met during the rise of GM biotechnology or other novel technologies on the rise. Sufficient information and education could be arranged in advance, to counteract or even intercept popular media in advance. By providing consumers with an adequate amount of information concerning the new technologies in advance, food scares can be prevented. Communication between the stakeholder could be increased, such as between scientists and media. While scientists tend to have more accurate information on the technology at hand, the media remains the primary source of information for most consumers (Vigani and Olper 2013, 37).

The second section of this thesis covered the regulatory aspects relevant to a nation's GM crop adoption and is essential for both domestic adoption as well as international stakeholders. Understanding China and Japan's domestic regulations for GM crops and biotechnology is not only relevant for domestic but also international policymakers. By offering transparency in the regulations of biotechnologies, future adoptions of both GM crops and products resulting from other biotechnologies could be eased. Based on past experience from China and Japan, this would be especially the case for labeling, which was the source of consumer opposition and caused numerous food safety scandals, such as in China the "Golden Rice scandal" (Yan et al.

2016, 388), or in Japan the "Starlink incident" (Nishizawa and Renn 2006, 47; Thibergien 2006, 31). Transparency concerning the approval process, which tends to be as complicated as time-consuming, is also important for international policymakers and traders to avoid additional costs or fines from importing countries (Mabaya et al. 2015, 581).

Both East Asian countries strive for sustainable development and higher food self-sufficiency that are advantages the adoption of GM crops has promised to offer. Due to similar struggles of China and Japan, such as limited natural resources and food security concerns, both countries rely heavily on food and feed import from big GM food-exporting nations, like the US, Brazil, and Argentina (Huang et al. 2017, 2936; Oliveira 2016, 353). Rising reliance on food trade causes a nation's food supply to be susceptible to potential exploitation as foreign policy tools in an unstable political environment (Zha and Zhang 2013, 465). Most of all, in the face of growing environmental challenges caused by climate change, industrialization, and urbanization, the search and adoption of alternative options to achieve food security become crucial (Kou et al. 2015, 2163). Despite both countries not finding themselves in immediate food security crises, they are still struggling with food self-sufficiency (Huang et al. 2017, 2939; Yoshii and Oyama 2016, 56).

Several of the beforementioned challenges, especially those caused by global warming, are not faced by China and Japan exclusively, but apply on the international level as well. Limitation on natural resources and the search for alternatives to reach sustainable development concerns nations worldwide. The global population is increasing, and so is the corresponding rise of food demands along with it. In order to achieve sustainable crop production and prevent the spread of food security crises, several researchers recommend to enhance nutrient use efficiency, decrease the use of agricultural chemicals, and increase grain yield through sustainable intensification of agriculture through biotechnology (Jiao et al. 2018, 761). The adoption of GM crops would not only offer a solution for East Asia but also apply to other countries with lower food self-sufficiency.

This research focused on the influential factors for the adoption of GM biotechnology in agriculture and the similarities and differences of each East Asian nation's approach towards this agri-biotech and its products. Even though there are also other technologies on the rise in the field of agri-biotech, such as the advanced CRISPR system, GM biotechnology is still the most commonly used agri-biotech in terms of enhancing crops and their productivity and remains one of the most widespread technological tools in food production (James 2015, 4;

Brookes and Barfoot 2016, 38). The knowledge gained from the key factors that influence the adoption of GM crops in China and Japan can pave the way towards the successful adoption of new technologies in the future, especially those designed with the similar cause to enhance agricultural productions. This applies not only to the two country cases of this thesis but also to other nations with the same intention.

Although there are currently only a few big GM crop exporters, GM biotechnology has opened up a huge market and will grow increasingly competitive. If China and Japan, two of the biggest GM crop importers, decide to make any changes in their regulations or consider GM food crop cultivation themselves, these potential alterations would have crucial consequences for the exporting countries. This is especially the case for Argentina and Brazil, both having extricated themselves from economic crises with the help of the adoption of GM soybeans (Leguizamón 2014; Oliveira 2016). However, high profits come with risks as well, as evidenced by China's economic crisis in 2015, which has jeopardized Argentina's economy considering China being its primary buyer of soybeans (Leguizamón 2016, 317).

The year of 2018 marked the 23rd year of commercialization of GM crops with 26 countries cultivating 191.7 million hectares of biotech crops, which is an increase of GM cropland area compared to the year before. With the exception of 2015, the number of land areas planted with GM crops rose for 22 years. According to the ISAAA, the adoption rates of the five largest GM crops cultivating countries are approaching saturation, with Argentina in the lead, followed by the US, Brazil, Canada, and India. Each of these countries has an adoption rate of over 90 percent (ISAAA 2018c, 2). The development of biotech policies can be detected in other Asian regions next to China and Japan. South Korea established a National Center for GM Crops (NCGC) in 2011 for the advancement of biotech crops as a solution in agriculture, similar to its neighbors (Park et al. 2018, 171). In Southeast Asia, the Philippines was the first nation to approve GM crop commercialization in 2002, followed by Myanmar in 2006 and Vietnam in 2015 (Neo 2019). While Thailand was one of the pioneers in developing biotech industries, it has not approved any commercialization and banned open field trials after 2001, as well as the import of any GM food or feed (FAO 2019c). Similar to China and Japan, political, economic, and judicial factors in these Asian countries are crucial but not the sole components for successful agri-biotech advancement and adoption. Especially small-scale farmers' interests can have an essential influence on the enforcement of necessary regulations (Larsson 2016, 1088).

In 2019, China announced its plan to approve the domestic cultivation of GM soybean and corn, which was implemented earlier this year and considered the first step towards commercializing GM grain production in the global market. China already approved both products for import and worked on the release biosafety certificates for GM corn and soybeans for years. Especially northeastern Chinese farmers could profit from domestic GM corn commercialization (Gu and Singh 2019; Gu and Patton 2020). Even though Japan has still refrained from any approaches towards domestic cultivation of GM food crops, it has continuously attempted to achieve approval for conducting field trials of GM crops, such as HT GM sugar beet in Hokkaido, as a start (ISAAA 2017). However, based on Japan's strong consumer resistance, which is most recently reflected in its "No! GMO Campaign," led by the Consumer Union of Japan (CUJ 2020), it is unlikely for Japan to initiate a proposal for domestic planting in the foreseeable future.

Nevertheless, agri-biotech is more than GM crops, with gene-edited crops on the rise. While Japan struggles with the commercialization of GM foods, experts seem to have learned their lessons from GM biotech and smoothed the use of CRISPR already early on. Both China and Japan already invested in the gene-editing technology CRISPR and its use in agriculture. Chinese researchers see in this agri-biotech a similar potential as GM biotech in its role to feed a growing population with limited resources. Researchers assume that China will follow in the US's footsteps in terms of regulatory decisions and exempt CRISPR products from GMO regulations (Cohen 2019). A Japanese advisory panel already confirmed the safe use of GE foods and their sale to consumers without safety evaluations. While the regulations on GM products are clear, GE foods do not necessarily have to undergo similar scrutiny for its commercialization. The lessons learned from GM biotech's benefits and challenges in commercialization has contributed to paving the way for new agri-biotech adoptions in the future. The application of a stable regulatory framework has proven to be essential for long-term advancement. Transparency throughout the introduction process, awareness campaigns, and platforms for communication of information among the stakeholders are key factors to ease public concerns, especially for technologies involving food (Normille 2019).

Despite the availability of alternative agricultural biotechnologies, reasons for the consisting high global adoption rate of GM crops are the growing need and the technology's comparatively solid establishment through over two decades of experience. The world population's food demand has reached a point that cannot be covered by conventional plant breeding solely anymore. GM biotechnology's role in filling the gap increases with the rising need for more food (Oliver 2014, 492). Therefore, the cultivation of GM crops is currently not only an option but a necessity. According to ISAAA, "biotech crops are essential, but are not a panacea." For all their enhanced features, GM crops are still food plants that require good farming practice to reach the promised profitable yields (2018c). Until new alternatives become well-established and accepted, GM crops will remain a crucial component of our food supply. This trajectory is not only the case for China and Japan but for all countries that import food or feed from the GM crops growing countries to fill their own gaps in production.

5.4. Limitations

This thesis has limitations and shortcomings, and thus represents only an introductive piece of research on a complex subject. The comparative analysis was conducted for two North-East Asian nations with big discrepancies not only between their sizes of population and surface area but also their political and socio-economic situation. Results from countries with similar sizes and resources would have been more easily compared with each other. If the range of research would allow, adding two countries with similar sizes might be worth considering for future studies with similar topics. Each factor was attempted to be dealt with equal attention; however, inconsistency still occurred regarding the depths of each treated factor, criteria, and indicator. Some seem to have received more attention than others due to the varying number of available sources. Primary sources were used as much as possible, although limitations of access and the language barrier, especially concerning Japanese sources, have been underestimated.

In the course of exploring and comparing similarities and differences between GM crop adoption in China and Japan, a composite framework was created by compiling three studies from peer researchers. Despite putting great emphasis on the choice of studies for the AF that both complement each other in their identified factors and fulfill the relevance for this thesis' topic, it was not possible to avoid overlaps entirely. In the case of some factors, already discussed information had to be repeated in order to sufficiently deal with the indicators that have been previously identified for the AF. One example would be the factor of advocacy by key political figures including advocated regulatory aspects, which still had to be treated in the second section again considering its role as the section originally intended for regulations. Another example would be the first factor, jurisdiction over biosafety, in the first section overlapping with the criteria of scope of approval execution in the first factor of the second regulatory section. Technical capacity represents another dimension that also caused overlaps with other factors since some of its criteria depend on other sectors' technical advancement.

This leads to the next limitation consisting of criticism towards the AF. Despite having fulfilled the thesis' purpose for comparative analysis, it has to be conceded that its capacity and range exceeded of the designated scope of this thesis. One out of the two sections dealt more in-depth might have already covered the required range of this thesis; however, explaining GM crops adoption without considering the regulatory aspects would have neglected an essential component of this topic again. One solution could have been narrowing the research down to exploring one single specific GM crop that might have brought more specific results than GM crops in general, such as GM soybean. However, this consideration was discarded due to initial concerns towards limited availability and accessibility of sources. Also, the absence of a common GM crop with equal impact on both China and Japan rendered the implementation of this idea moot since neither of the two countries has started cultivating biotech food crops on a large scale at the time this research was conducted.

Nevertheless, by the end of this thesis, it has to be admitted that zooming on the smallest possible common denominator among the GM commodities would have been the better choice for more focused results. Having registered this, it might also be worth considering introducing sub-indicators for each factor in this thesis' AF for more accurate results, especially for the regulatory section. During the research for the empirical part, I have discovered that each determined indicator could have been broken down into even smaller and more specific elements. Another solution could be to narrow down the topic by focusing on fewer factors and examining those more in-depth instead of attempting to cover a broader range of factors.

Despite the beforementioned limitations, it has to be considered that several of their revisions would have enlarged the content's range and exceeded the scope of this thesis. While the individually compiled AF turned out to be not as perfect as expected, I hope to have achieved a first step towards comparing China and Japan's approaches towards GM crop adoption and explained the extent of similarities and differences to which these nations have practiced it. On a broader scale, I hope to have raised awareness about both the concerns and possibilities that agri-biotech, specifically GM biotechnology, can offer.

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Appendix

Abstract

The global population is continuously rising, which increases the demand for food, while natural resources remain limited. Therefore, food production needs not only to be raised in the amount of its outputs but also to reach higher efficiency and sustainability in its process. Climate change only adds to the already existing environmental challenges, resulting in more pressure for agriculture, which has to improve yields and enable steady supply in a world with varying environmental circumstances. Conventional breeding cannot solely meet these rising demands and challenges; therefore, solutions have been searched and found in agri-biotech with GM crops pioneering in grain production. China and Japan are among the countries that have incorporated GM crops into their food and feed supply chain to fill the gaps in production through investments in its trade, research and cultivation. This thesis offers a comparative assessment of the GM crops adoption by China and Japan through a composite analytical framework based on existing pieces of research from peers.

Abstrakt

Mit stetig wachsender Weltbevölkerung steigt der Bedarf an Nahrung, während die Menge an natürlichen Rohstoffen jedoch begrenzt bleibt. Daher muss die Nahrungsmittelproduktion nicht nur in dessen Menge erhöht werden, sondern auch an Effizienz und Nachhaltigkeit während des Prozesses gewinnen. Umweltprobleme werden zunehmend durch den Klimawandel verstärkt und verursachen dadurch unter anderem Verluste in der Getreideproduktion. Die Landwirtschaft steht daher unter Druck höhere Erträge trotz zunehmender Herausforderungen zu erbringen. Lösungen für diese Herausforderungen haben sich innerhalb der landwirtschaftlichen Biotechnologie ergeben, in der Form von genmanipulierten Nahrungsmitteln. Sowohl China als auch Japan haben sich dieser Biotechnologie angeeignet durch Investierungen in deren Handel, Forschung und Kultivierung. Diese wissenschaftliche Arbeit dient einer vergleichenden Forschung der Aneignung von genmanipuliertem Getreide in China und Japan anhand eines selbst-zusammengestellten analytischen Forschungsgerüsts.