

Patterns and Determinants of GMO Regulations: An Overview of Recent Evidence

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An increasing set of evidence has been reported on how countries set standards on genetically modified food and their subsequent economic effects. Studies typically contain some empirical evidence and some theoretical explanations of the data. However, to date, limited effort has been posed on systematically reviewing the existing evidence and its implications for policy. This article contributes to the literature by bringing together a summary of the most recent published evidence on patterns of GMO regulation and their determinants, as well as their economics implications for trade and firms' global strategy.

Key words: GMOs, regulation, European Union, GM-free.

Introduction

The global regulatory system for genetically modified (GM) crops and foods is complex and heavily fragmented, raising growing concerns about its effects on international trade and ultimately on food-security issues. The stringency of public regulations on genetically modified organisms' (GMO) adoption and commercialization of important rich regions or countries—such as the European Union (EU) and Japan—has contributed to the complexity of the GMO regulatory system through the progressive diffusion of private GM-free standards by leading retailers. Public and private GMO standards interact together, rendering the whole system costly and unpredictable.

An increasing set of evidence has been reported on how countries and retailers set standards on GMOs and their subsequent economic effects. Studies typically contain some empirical evidence and some theoretical explanations of the data. However, to date, limited effort has been made to review the existing evidence on the economic impact of different GMO legislations and its implications for public and private standards adoption. This article contributes to the literature by bringing together a summary of the most recent published evidence on differences in GMO legislation and their determinants, as well as their economic implications for trade and firms' global strategies.

In the next section, we propose a summary of the current clusters of GMO regulations worldwide by exploiting the GMO index recently developed by Vigani and Olper (2013), focusing particularly on the political and economic determinants. Then, we review the current theoretical and empirical evidence concerning two key emerging issues of GMO regulation and standards. Next, we consider the issue of the interaction between private and public GMO standards, followed by a sum-

mary of the current evidence about the effect of GMO regulation on international trade. The final section draws some concluding comments.

Differences and Clusters in GMO Regulations: Theoretical and Empirical Explanation

The Global Landscape of GMO Regulation

Starting from the mid-1990s, an increasing number of countries have been setting regulations concerning the use and commercialization of GM crops and products. The leading countries setting such regulations have been the EU and the United States (Gruère, 2006). Acting as first movers, they draw two opposite regulatory approaches, creating historical benchmarks for follower countries. These approaches are commonly known as the “precautionary principle” and “substantial equivalence.” The first, followed by the EU, provides that any product produced with or derived from transgenic crops is subject to *ad-hoc* regulation in order to guarantee to consumers the “right to know”; the second, followed by the United States, permits substantially equivalent products to be exempted from specific regulation. Despite the underlying opposite approaches, both countries recognized some common pieces of GMO regulation. These pieces cover different aspects of the cultivation and commercialization of GM crops, such as approval, risk assessment, labeling, traceability, and coexistence; but also aspects related to the development of new GM crops, such as rules for laboratory and field trials and intellectual property rights (IPR) protection (for example, the EU patent legislation forbids claiming specific plant varieties in patents, while in the United States this is allowed).

Table 1. Groups of countries clustered by level of GMO regulation restrictiveness.

Cluster	Countries	N. of countries	GMO index value
1	Hong Kong	1	0.10
2	Bangladesh, Peru, Sri Lanka, Turkey, Ukraine, Venezuela	6	0.15
3	Israel, Jamaica, Kenya	3	0.20
4	Canada, Guatemala, Philippines, Singapore, South Africa, Taiwan, Vietnam	7	0.30
5	Chile, India, Indonesia, Malaysia, Mexico, United States	6	0.35
6	Argentina, Thailand	2	0.40
7	Colombia, Russia, Saudi Arabia, South Korea	4	0.45
8	Brazil, China	2	0.50
9	Australia, Switzerland	2	0.55
10	Norway, Poland, Spain, United Kingdom	4	0.60
11	Germany, Greece, Ireland, Luxemburg, New Zealand, Romania, Slovakia, Slovenia, Sweden	9	0.65
12	Estonia, Finland, Japan	3	0.70
13	Austria, Belgium, Czech Republic, Denmark, France, Hungary, Italy, Netherlands, Portugal	9	0.75
14	Zambia, Zimbabwe	2	1.00

Notes: the GMO index is taken from Vigani and Olper (2013). Hong Kong and Taiwan have legislative autonomy, and for this reason are treated separately from China.

Following the steps of the EU and the United States, many other countries started formulating national GMO regulations, assuming totally or partially one of the approaches proposed. As a result, the actual global landscape of GMO regulation is extremely fragmented. GMO regulations strongly differ worldwide, creating groups of countries sharing similar regulation or similar levels of restriction.

Table 1 depicts the actual fragmentation of the GMO regulation around the globe, showing clusters of countries with similar levels of restrictiveness. Table 1 is based on the GMO index developed by Vigani and Olper (2013). The GMO index is a measure of the restrictiveness of six pieces of legislation composing the overall biotech regulation, namely the approval process of new GM crops for cultivation and commercialization, the risk assessment of new GM crops or products, the labeling of products containing GMOs, the traceability of GM products, the coexistence measures for the cultivation of GM crops along with traditional and/or organic crops, and the membership of the country in international agreements concerning GM crops and products (i.e., the Codex Alimentarius and the Biosafety Protocol).¹ Each component is scored with an increasing value and the final index is obtained by summing the component scores and normalization, so that the index varies from 0 to 1, where higher values correspond with a higher level of restrictiveness of the overall regulation or of the single piece of legislation (see Vigani & Olper

[2013] for details on the index computation). Countries with similar index values share a certain degree of similarity in the regulation.

The GMO index and each of its components (except international agreements) are positively correlated with the index of patent protection developed by Ginarte and Park (Park, 2008), suggesting that the GMO index (indirectly) captures the level of IPR protection of GM crops. The overall correlation between the two indices is 0.30, and it ranges between 0.17 (coexistence) and 0.40 (traceability).

The GMO index shows 14 groups of countries.² In each group, countries share the same aggregate index value. At the lower extreme, Hong Kong is the region with the least restrictive regulation, which is not surpris-

1. *Despite the efforts of the Codex Alimentarius and of the Biosafety Protocol in searching for international agreement on labeling and rules for the trans-border movements of GMOs, to date there is no consistent and harmonized set of rules to regulate GMOs. This is partially due to the different food security strategy in developing and developed countries.*
2. *Vigani and Olper (2013) calculated the GMO index for the year 2009. From 2009 to today some countries have slightly modified their GMO regulation (e.g., Germany, Peru, and Turkey); hence, today they might appear in a different cluster. However, the goal here is to document the global fragmentation of the biotech regulation and the existence of such clusters of countries and not to provide the exact current restrictiveness.*

ing given that it is a very trade-intensive country with limited agricultural production capacity, hence any restrictive regulation on production and commercialization would result in disproportionate costs. On the other extreme, Zambia and Zaire are GM-free countries, meaning that they forbid any cultivation and circulation of GM crops, as well as of any product containing GMOs.

Developing countries tend to create groups with an index value below 0.5, while OECD (Organisation for Economic Co-operation and Development) countries are uniformly distributed throughout the clusters. The level of economic development itself does not explain the positioning of a country in a certain group. While Groups 2, 6, and 8 contains exclusively developing countries, Groups 3, 4, 5, and 7 mix very rich economies (e.g., Canada, Singapore, Taiwan) with poor ones (e.g., Philippines and Vietnam). However, the most restrictive countries are developed and mainly members of the EU (Groups 9 to 13; see next section for a detailed description of the EU situation).

Explaining the differences in GMO regulation across countries and the formation of clusters is a challenging task because there are many factors affecting the formulation process of the regulation, and different stakeholders and national food security strategies are involved. It is so complex that one necessarily misses some important factors in a confined context. For these reasons, our review investigates theoretical, empirical, and legislative sources. The theoretical literature mainly disentangles and analyzes each factor singularly, while empirical evidence puts together several driving factors.

Starting from the theoretical point of view, different GMO regulations reflect the utility of the various groups involved in the formulation of the regulation—decision makers, traders, consumers, farmers, and agrochemical and seed companies. Each group has different interests and preferences driven by the welfare and rent distribution effects of different regulations (see Lapan & Moschini, 2004; Moschini, 2008; Veyssiere & Giannakas, 2006). From a political economy point of view, there are at least three key factors explaining the formulation of the GMO regulation and the creation of clusters of countries identified by the theoretical literature: consumer acceptance and farmers/business interests, trade and comparative advantage factors, and the structure of the media market. Figure 1 provides an overview of the process and of the factors influencing the regulation formulation and their interaction.

The political economy perspective allows for the participation of different interest groups in the formula-

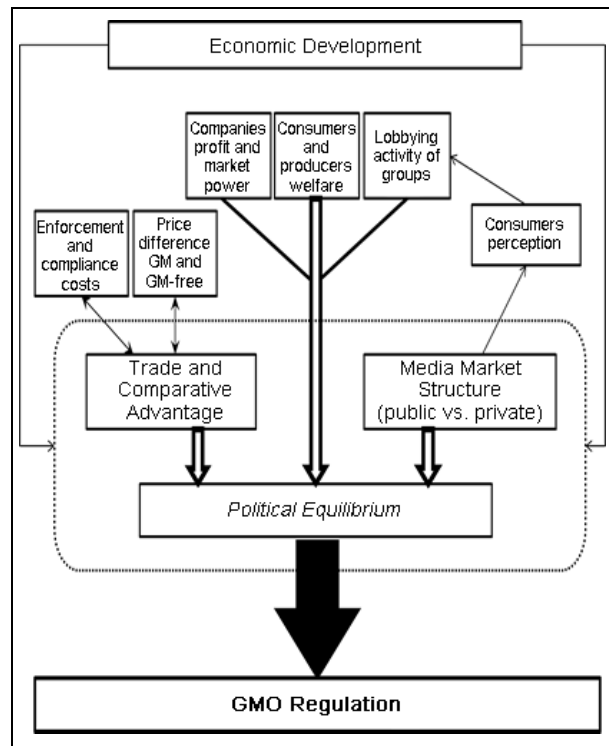


Figure 1. Conceptual framework and relation of the factors determining the formulation of GMO regulations. The political equilibrium is the interactions of all the forces: trade/comparative advantage, media market, profits, welfare, and consumer/company lobbying activities (mediated by the media structure).

tion of national regulations. Fulton and Giannakas (2004) showed that the political equilibrium and the regulatory outcome depends on the lobbying activity and capacity in producing political pressure of consumers, producers, and companies, all of which have different interests: consumer welfare is reduced when there is aversion to GM products and costs for identity preservation of products are high; producer welfare is reduced when consumer aversion and GM seed costs are high; companies are driven by profit maximization but are constrained by low demand for GM seeds and company market power. Gruère, Carter, and Farzin (2009) used a proportional voting model where producers, green party, and voting pressures affect the formulation of labeling policies, which are decided mainly on the basis of production- and trade-related interests. Also Vandemoortele (2011), through a dynamic model of government decision making, illustrates the dominant role of trade interests (in particular protectionist interests) and consumer preferences to explain the differences in GM regulation between the United States and the EU. This literature

clearly illustrates how complex is the achievement of a political equilibrium, and how the composition of the society in a given country, and the weights of the single groups, internally affects the policy outcome.

The political economy literature clearly points to trade as one of the major factors affecting GMO policies, and some authors directly explained the formation of regulation as a function of trade interests. In Lapan and Moschini (2004) the main drivers are compliance costs, consumer preferences, income level, and price differences between GM and GM-free products. They used a two-country partial-equilibrium model to show that biotech regulation may redistribute income among trading partners—to the benefit of importing countries—depending on the costs incurred by regulation. Similarly, with a Krugman-style trade model, Tothova and Oehmke (2004) showed that countries select the biotech regulation taking into account the costs of enforcement, the loss of productivity, and the (potential) loss of trade.

The third important factor analyzed by the theoretical literature is the structure of the media market. Many authors (Kalaitzandonakes, Marks, & Vickner, 2004; Swinnen, McCluskey, & Francken, 2005; Verbeke, Ward, & Viaene, 2000) highlighted that the media market has a pivotal role in shaping consumer perception and preferences towards food standards. In particular, McCluskey and Swinnen (2004) argue that the media market differently affects the consumers' perception depending on the country's economic development and on the media ownership. "Bad" news provokes higher consumption of media than "good" news, inducing private media to publish bad rather than good news to maximize profit. Thus, private media are more likely to highlight potential risks associated with biotechnology than benefits, affecting the consumers' perception of GM products and, in turn, their preferences toward GMO regulations. Curtis, McCluskey, and Swinnen (2008) argue that the higher cost of information in developing countries, and the consequent lower consumption of biased information on biotechnology, can induce more favorable consumer perceptions of GMOs, partly because media in developing countries are often controlled by governments that seek to lower the risk perception of consumers. This is confirmed by Vandemoortele (2011), who shows that in developing countries, the relative higher cost of media access leads to lower media consumption (consequently, consumers are less exposed to reported GMO risks), while the media structure in rich countries increases attention to risk. This bias affects GMO regulation preferences and,

hence, media greatly contribute to forming consumer attitudes on GMO standards.

All the above theoretical hypotheses found a positive confirmation in the empirical literature. In particular, Vigani and Olper (2013) tested all the above theoretical hypotheses, explaining which factors drive the formulation of restrictive GMO regulations.

First, they tested the effects of the political environment, showing that in countries with a democratic political system, the greater representation of the population and of different interests pushes policymakers to take into account the different preferences. This concerns both GMO and environmental regulations, which go hand-in-hand given the environmental implications of the release of GM crops in the fields. Indeed, countries with greater demand for restrictive environmental regulation have also more restrictive GMO regulations. Moreover, a strong link between the donations to political parties and lobbying activity of green organizations and associations of organic producers results in more restrictive GMO regulation. However, farmer groups are typically well organized, and they generally lobby in favor of cost-saving, productivity-enhancing innovations (i.e., GM crops).

Second, trade relationships and agreements create self-selecting groups of countries sharing similar regulations. This is not surprising if we consider the cases of the EU and Japan. They are rich, net importers of agricultural commodities (meaning a lower comparative advantage in the agricultural production that can trigger protectionist behavior). The safety of GM products is a sensitive issue for consumers in both countries (Grùère, 2006), hence exporters who want to access these markets need to comply with their food standards. However, there is a potential opposite effect between regulation and trade. Indeed, the enforcement and compliance costs coming from restrictive regulations can increase trade costs, thus impeding those exporters who cannot afford the higher costs. In this sense, regulation can act as a protectionist tool that benefits domestic producers (Anderson, Damania, & Jackson, 2004).

Vigani and Olper (2013) point to sectorial differences as drivers of the regulation formulation. Intensive farming systems (technology oriented) versus sustainable, environmentally friendly systems (with diffused organic production) have come to characterize the dual opposition between pro- and contra-GM crops use.

Finally, the role of mass media in influencing the formulation of GMO regulation is confirmed, building on the intuition of Olper and Swinnen (2013). The target of private media is the largest group of the society,

Table 2. European Member States clustered by similar value of GMO index and by pieces of GMO regulation.

Cluster	Countries	Risk					Coexistence	GMO index
		Approval	assessment	Labeling	Traceability	Agreements		
1	Poland, Spain, UK	0.75	0.67	0.75	0.67	1	0.00	0.60
2	Germany, Greece, Ireland, Luxemburg, Romania, Slovakia, Slovenia, Sweden	0.75	0.67	0.75	0.67	1	0.25	0.65
3	Estonia, Finland	0.75	0.67	0.75	0.67	1	0.50	0.70
4	Austria, Belgium, Czech Republic, Denmark, France, Hungary, Italy, Netherlands, Portugal	0.75	0.67	0.75	0.67	1	0.75	0.75
Average for the EU		0.75	0.67	0.75	0.67	1	0.44	0.69

Note: the GMO index is taken from Vigani and Olper (2013).

which can guarantee greater media consumption. In developed countries, the farm population is typically small, and private media targets mainly consumers that are oriented toward food safety standards. On the contrary, in (agriculture-based) developing economies, the farm population is relatively large, and private media promote agricultural innovations and policies that favor farmers' interests. Vigani and Olper (2013) not only find a significant confirmation of this relationship, but they also show that media variables contributed substantially to the overall explanation of differences in GMO regulations.

Comparison across EU Member States

Currently, the only GM crop authorized for cultivation in the EU is one event of Bt maize resistant to insect pests. In 2012, Bt maize was cultivated in Czech Republic, Portugal, Romania, Slovakia, and Spain, on a total area of roughly 129,000 hectares (about 0.7% of the total maize acreage in the EU27), of which almost 90% are in Spain; this is the only Member State where the GM surface is increasing.

Food regulations are common to all the Member States, usually ruled by directives and/or regulations. In the framework of the GMO regulation, there are some pieces that are ruled by recommendations,³ which allow

for a certain degree of heterogeneity, explaining the differences across Member States. Using the GMO index (Vigani & Olper, 2013) and its components, Table 2 reveals that the source of heterogeneity in the EU regulation is coexistence.⁴ The framework of GMO regulation in the EU is built on a number of acts: Directive 2001/18/EC on the deliberate release into the environment of GMOs; Regulation No. 1829/2003 concerning GM food and feed; and Regulation No. 1830/2003 concerning the traceability and labeling of GMOs and the traceability of food and feed products produced from GMOs. The directive and the two regulations rule the approval, the risk assessment, the labelling, and traceability, which are indeed compulsory and common to all Member States.

With respect to coexistence, Article 26a of Directive 2001/18/EC states that Member States may take appropriate national measures to preserve coexistence between and among agricultural fields and experimental field trials for the development of new GM crops, but it does not provide obligations nor suggests specific measures. Recommendation 2003/556/EC on "guidelines for the development of national strategies and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming" provides a list of general principles and technical measures to help Member States develop national strategies for coexistence. However, Recommendation 2010/C 200/01 allows more flexibility, as Member States can take into account their local needs of organic, conventional, and other types of crops, providing for stricter measures or

3. Regulations are direct forms of EU law; they have binding legal force throughout every Member State, on par with national laws. EU directives must be achieved by a member state's national authorities, which adapt their laws to meet the directives' goals but are free to decide how to do so. Recommendations differ from regulations and directives in that they are not binding for Member States; rather, they are indirect actions aiming at the preparation of legislation in Member States.

4. The purpose of coexistence is to guarantee consumers and farmers the possibility of choice between GM, traditional, and organic products.

to restrict GMO cultivation from large areas, effectively creating “GM-free areas.”

The non-obligatory nature of Recommendation 2010/C 200/01 gives space for different administrative and segregation measures across Member States, provoking different production costs. While the majority of the Member States adopted a legislative approach to regulate coexistence, Spain addresses it by means of non-legislative instruments and Italy by a combination of legislative and non-legislative measures; the UK, Ireland, and Poland do not envisage any coexistence strategy in the near future, as the cultivation of GM crops on their territory has been considered unlikely to take place (European Commission [EC], 2009).

Many Member States require farmers to notify the competent authority of GM crop cultivation prior to the sowing and to inform neighboring farmers located within a defined distance (the distance may vary depending on the Member State). Moreover, the record of GM crop cultivation must be kept for a period ranging from 5 to 10 years after harvest in many Member States, while Belgium, Denmark, Estonia, Italy, Latvia, the Netherlands, and Slovakia also require GM crop growers to undergo mandatory training on implementation of the segregation measures.

The segregation measures at the farm level involve different practices. The species so far addressed include maize and, in some Member States, potato, sugar beet, fodder beet, wheat, soybean, and oilseed rape. Spatial segregation is generally based on isolation distances between GM crop fields and neighboring non-GM fields with sexually compatible crops. Isolation distances range between 25m (the Netherlands) and 600m (Belgium and Slovenia) towards conventional maize, and between 50m (Portugal) and 600m (Belgium and Slovenia) towards organic maize (EC, 2009). The isolation distances can sometimes be partially or fully replaced by buffer zones, in which sexually compatible, non-GM crops are grown, harvested, and treated as GM plants. In France and Italy, buffer zones are mandatory supplements to isolation distances.

In case of damages due to admixture between GM and non-GM crops, several Member States established compensation funds (usually with contributions from growers); however, in France and Italy, insurance or other forms of financial guarantee against these damages is compulsory (although neither of the two Member States has this kind of insurance available yet).

Because coexistence measures are heterogeneous, the EU provides some tools for their harmonization across Member States. One is the network group for the

exchange and coordination of information concerning coexistence of genetically modified, conventional, and organic crops (COEX-NET), which is composed of representatives from Member States and administered by the EC. It aims to foster the exchange of information based on results of scientific studies as well as on best practices. Also, the European Coexistence Bureau (ECoB),⁵ composed of Member State and EC representatives, produces crop-specific guidelines for technical segregation measures and explores with Member States possible ways of minimizing potential cross-border problems related to coexistence. Finally, the European GMO Socio-Economics Bureau (ESEB),⁶ consisting of scientific experts nominated by the Member States and experts from the European Commission, develops reference documents to organize and facilitate the exchange of technical and scientific information on the socio-economic implications of the cultivation and use of GMOs.

GMO Regulation and Formation of Private Standards

One of the major effects of the differences in GMO regulations concerns the agri-food sector and the formation of voluntary (private) standards on ingredients derived from GM crops that are used by private companies, such as retailers and food multinationals. The presence of GMOs in food products typically attracts consumer attention, often alarmed by non-governmental organizations (NGOs) and green parties, which argue that the safety of GM crops is still unclear (Takeshima & Gruère, 2011); this typically generates preferences for differentiated products. As a reaction, some global retailers sell private-label products not containing ingredients obtained by GM crops (GM-free products; Vigani & Olper, 2014).

Although consumer preferences are important drivers of GM-free private standards, they are not the only determining factor. The adoption of GM-free standards is a complex function with its roots in several theoretical factors. One of the factors is the structure of the supply chain and the interaction between retailers, manufacturers, and producers; this structure determines the relative bargaining power along the supply chain and the vertical quality differentiation structure (von Schlippenbach & Teichmann, 2012). Indeed, in the case of GM-free standards, the coordination of the supply chain is a *condicio sine qua non* for the creation of identity-preserved (IP)

5. <http://ecob.jrc.ec.europa.eu/>

6. <https://ec.europa.eu/jrc/en/eseb>

supply channels that guarantee the supply of certified GM-free products. An additional factor (concerning the political economy of food standards) is the link that exists between private standards and the level of the public standards (Vandemoortele & Deconinck, 2013). Companies are induced to adopt more restrictive private standards over and above government requirements in order to induce lower (and less costly) public minimum quality standards (MQS) by the government (McCluskey & Winfree, 2009).

The empirical evidence on the effects of GMO regulation and policies on the adoption of GM-free standards by private companies are recent and limited in number, but they are seminal and important analyses. Gruère (2006) conducted a survey on labeled GM and GM-free products in supermarkets in Canada and France in order to analyze the effects of new labeling regulations adopted in 2004 in the two countries. He found that after the introduction of the voluntary labeling by Canadian authorities, retailers were selling labeled GM-free organic products; and in France, there were no products labeled as 'containing GM ingredients,' although the new public regulation allowed for it. The author concludes that both regulations failed in providing consumers with the 'right to choose' among different products. Gruère and Sengupta (2009) studied the effects of GM-free private standards adopted by food companies on the policymaking of biosafety regulation in developing countries. They found that GM-free private standards can indirectly induce irrational policy decisions in developing countries because the fear of export losses can induce excessively precautionary decisions.

The recent work of Vigani and Olper (2014) extensively explained the role of public regulation in the formation of retailers' GM-free private standards, taking into account both the vertical differentiation and the political economy factors, while controlling for several country-specific characteristics, such as historical and geographical conditions, infrastructure, sectorial conditions, and the quality of institutions and economic development. Controlling for double-causality (i.e., the public standard may influence the adoption of the private standard, and vice versa the presence of private standards on the markets may influence the formation of public standards), they show that different GMO regulations across countries induce retailers to adopt private standards in order to choose the quality level that minimizes the negative effects on costs and revenues (McCluskey & Winfree, 2009). Moreover, retailers sell GM-free products in order to overcome compliance and logistic costs due to different requirements in different

countries and to avoid problems of asynchronous or asymmetric approval, allowing, at the same time, to exploit the non-GM IP supply channel to the international scale without incurring different labeling thresholds.

The adoption of GM-free private standards can have important impacts on producers, especially in developing countries. Indeed, retailers and food companies have strong influences in shaping the agricultural sector in producing countries, through foreign direct investments (FDI) or through the demand for products not otherwise cultivated (Maertens, Colen, & Swinnen, 2011). Hence, producing countries can lose important benefits derived from the use of GM crops, such as increased yields (higher input-use efficiency and reduced crop losses) and simplified crop management (lower pesticides and fuel on-farm and reduced- or zero-tillage systems), and, consequently, lose important contribution toward food security (Wesseler, Scatasta, & El Hadji, 2011).

GM crops also have important direct and indirect environmental benefits for developing countries. The reduction of pesticide applications in Bt crops is a major direct benefit, with fewer chemicals released into the environment and reduced farmers' exposure to chemicals. The most important indirect effect of the use of GM crops is on land use. The fast demographic growth in developing countries increases the demand for food, putting pressure on agricultural land and increasing the opportunity cost of land uses. As a result, natural habitats are under threat to be converted to agricultural activities; the gain in agricultural land productivity is fundamental to reducing the pressure on habitats (Wesseler et al., 2011). Moreover, the simplification in management practices enhanced by GM crops may result in lower on-farm fuel consumption and greenhouse gas (GHG) emissions. Finally, reduced or no-tillage practices can help maintain soil biodiversity, reduce soil erosion, and increase soil organic matter, thus improving the structure and water-holding capacity of soils. All these environmental benefits are potentially lost in the GM-free production.

A particular case of GMO private standard is represented by "GM-free" labels, meaning dedicated private labels for foods obtained without GM ingredients. The adoption of GM-free labels was driven by European retailers in the early 2000s, especially in Austria and Germany for dairy, poultry, and pork products. In 2008, Germany enforced the first national act providing a legal base for GM-free labels. Despite similar GM-free label regulations likely diffusing among European countries, Tillie, Vigani, Dillen, and Rodríguez Cerezo

(2012) showed that many global retailers are not willing to adopt such labels because of uncertainties both on the supply and demand sides. Retailers adopting GM-free labels must purchase constant amounts of non-GM ingredients, but to reduce the production (and price) volatility of non-GM commodities, they must rely on certified and IP supply channels and on traceability systems, all of which incur increased production costs. Moreover, labels such as “containing GMOs” can be perceived by consumers as hazard warnings (even if the GM ingredients have been approved after a health and environmental risk assessment), thus affecting the sales of non GM-free products and, potentially, the consumer’s perception of the overall retailer’s “way of doing business.” Hence, many retailers prefer not to engage in private labeling regimes, continuing to purchase the ingredients from the traditional market and building consumer confidence through public regulation.

In response, the diffusion of GM-free standards seems to suffer a significant contraction recently. Beginning in 2012, six UK retailers (ASDA, Morrisons, Tesco, The Cooperative, Marks & Spencer, and Sainsbury’s) abandoned their GM-free requirements on poultry products, explaining that the difficulties of UK farmers in sourcing enough GM-free feed make it impossible to maintain the standard.⁷ Similarly, in February 2014, the German poultry farmers association issued a press release stating that, after 14 years of exclusive use of non-GM soybeans in poultry production, they will now allow producers to feed animals with GM soybean (Rehder, 2014). The decision was made due to several factors—the expected 50% cut of Brazilian production of non-GM soybean, the increasing contamination rates with GM soybean into non-GM soymeal, the volatile price spreads between non-GM and GM soymeal, and the softer influence of NGOs on German retailers.

GMO Regulation and Trade: Evidence

Complex and stringent GMO regulations not only impact the domestic agricultural sector, but also have important implications for the international trade of agricultural commodities. Several authors showed that the stringency of the GMO regulation of major global importers of agricultural products, such as the EU and Japan, could represent a serious problem for exporter countries, in particular for developing countries where economic development is based on the agricultural sec-

tor (see, e.g., Anderson & Jackson, 2004; Tothova & Oehmke, 2004).

While some major exporters, such as Brazil and the United States, adopt ‘soft’ GMO regulations and extensively cultivate GM crops for domestic consumption and export, other smaller countries are challenged by the trade-off between adopting GM crops for their expected production and agronomic benefits and the potential loss of access to rich markets with strong consumer opposition to GMOs (Gruère et al., 2009). These uncertainties about production and trade freeze the development of the GMO regulation in many developing countries, creating a regulatory limbo that translates in a “wait and see” position in order to avoid losing any production or trade opportunity (Gruère, 2006).

Several authors have tried to clarify if and how much GMO regulations affect trade. Cadot, Suwa-Eisenmann, and Traça (2001) discussed the ‘regulatory protectionism’ aspect of the European regulation, arguing that, in the context of increasing global tariff reduction, tariffs can be substituted by restrictive GMO standards aiming to protect the domestic market. The authors reported evidence that the European GMO regulation did not have negative repercussions on the US exports of corn seeds, but they did find negative effects on other forms of corn, suggesting that the behavior of downstream traders and food retailers regarding GM products were more important than the government decisions. On the contrary, Disdier and Fontagné (2010) estimated the effects of the EU *de facto* moratorium, concluding that the moratorium, as well as other European GMO regulations, had negative trade effects on exporting countries. Veysiere (2007) studied the dilemma facing large exporting countries of agricultural products. Such countries have to determine whether to approve GM products with or without a labeling regime. Results show that GM product approval is optimal under a labeling regime, while non-approval is optimal in the absence of mandatory labeling requirements. Gruère et al. (2009) evaluated the importance of socio-economic factors in the selection of GM labeling regulation, showing that production and trade has an important role on labeling choices, highlighting the importance of treating GM regulations as potentially endogenous to trade flows.

Among the different authors, Vigani, Raimondi, and Olper (2012) provided decisive evidence on the effects of different levels of restrictiveness of GMO regulation between trade partners of agricultural commodities. They used a bilateral trade gravity equation introducing a variable measuring the bilateral differences in GMO

7. <http://www.farming.co.uk/news/article/8238>

regulation based on the GMO index (see above section entitled “The Global Landscape of GMO Regulation”), controlling for the endogeneity of regulation. The trade flows involved three major potential food and feed GM products (maize, soybean, and rapeseed) and cotton products related to the agri-food sector (seeds, oils, and cake for feed ingredients). The analysis clearly shows that pairs of countries with strong differences in regulation trade significantly less. This negative effect is particularly driven by three pieces of regulation—labeling, the approval process, and traceability. The products most affected are corn, soybean, and rapeseed; no significant impact was found on cotton, as it is only partially involved in the agri-food chain. Moreover, Vigani et al. (2012) analyzed different levels of economic development, finding that different biotech regulations particularly negatively affect developed and emerging countries. The authors conclude that a process of global harmonization of GMO standards would have a large, positive trade effect, especially with regard to labeling policies.

Besides the direct trade effects of restrictive or heterogeneous GMO regulation, another indirect trade effect can emerge from the so called “asynchronous approval”—when a GMO is approved for cultivation and commercial use in food and feed in some countries, but not in their commercial partners. The presence of a small percentage of unapproved GM products mixed with non-GM commodities can result in trade rejection by major importers, with costs for all traders involved. This possibility is particularly sensitive for the EU and its trade partners, given the large imports of commodities in the EU and its zero-tolerance policy—the tolerance threshold for unapproved GM events in the EU is zero. Moreover, the average length for the approval of a GM event in the EU is about 3 years (Nowicki et al., 2010), which is pretty long in terms of trade. Consequently the risk of temporal or permanent trade disruption due to asynchronous approval increases.

Some authors estimated the trade impact of asynchronous approval. Backus et al. (2008) collected evidence on how EU policies have already led to difficulties with the import of raw materials from exporting countries where GM events have already been approved or are under development. Philippidis (2010) examined the impact of trade disruptions caused by asynchronous GMO approvals on feedstuff prices between the EU and Argentina, Brazil, and the United States, finding that the loss of all three suppliers can generate a 500% increase in feed costs within the EU market. Because of price increases and reductions in

production, Philippidis (2010) finds significant erosion of the competitiveness of the EU livestock industry, with poultry and pig meats production declining about 40% to 50%.

In 2010, Nowicki et al. executed an extensive study on the implications of asynchronous approvals for EU imports of animal feed products, concluding that asynchronicity combined with the zero tolerance can provoke disruptions in the bilateral trade flows between the EU and major exporters, resulting in changes in trade patterns at global level. Moreover, the domestic prices of maize, soybean, and soybean products can significantly increase in the short period (from 5% to 210% depending on the product and the scenario).

Conclusions

This article reviewed theoretical and empirical evidence on the formation of biotech regulations at the national level, highlighting two major effects that heterogeneous regulation can have on a global scale, namely the adoption of GM-free private standards by global retailers and food companies and disruptions in the international trade of agricultural commodities.

The GMO regulation of a sample of countries is divided into 14 groups in which countries share similar regulations. The formulation of a given GMO regulation is not only a function of the stage of economic development but it is primarily a result of the domestic political equilibrium, which in turn is influenced by trade and comparative advantage, the rent distribution among the different groups of the society and their lobbying capacity, and the consumer perception of the safety of GMOs. Importantly, the political equilibrium is mediated by the structure of the media market, which has a pivotal role in shaping consumer perception. We also find an important heterogeneity in the biotech regulation of EU Member States, which are clustered into four groups. The differences across Member States are driven mainly by the flexibility on coexistence strategies given by Recommendation 2003/556/EC.

The evidence shows that harmonization of GMO legislation and a smooth approval process of GM events may help trade in agricultural commodities. Harmonization would lower trade costs due to different regulation requirements and would reduce trade disruption due to adventitious presence of unapproved GM events. The introduction of GM-free products in the agri-food chain is not only a response to different consumers’ preferences, but it is a strategic reaction of private companies to overcome compliance and logistics costs derived

from different requirements in different countries and to avoid problems of asynchronous or asymmetric approval. This allows firms to exploit the non-GM IP supply channel to achieve international scale that would not be possible with different labeling thresholds.

The decision by private companies to adopt a voluntary standard that is globally homogeneous suggests that private companies self-compensate with voluntary actions in response to the lack of harmonization in the public regulation.

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Authors' Notes

The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.