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GMO Standards, Endogenous Policy and the Market for Information

Abstract. The paper develops a composite index of GMO standards restrictiveness for 60 countries, assigning objective scores to six different regulatory dimensions. Using this index and its components, we empirically investigate the political and economic determinants of GMO regulations for 55 countries, controlling for spatial autocorrelation. Results show that many of the determinants highlighted in the theoretical literature, such as the structure of the agricultural sector and the institutional environment are important determinants of the restrictiveness of the GMO regulation. As a key result there emerges a prominent role of the market for information, showing that the structure of domestic mass media (public vs. private) is an important driver of GMO standards.

***Key words*:** GMO standards, political economics, media market
***JEL* classification:** D72, Q13, Q16, Q18

1. Introduction

In recent decades, the rapid diffusion of genetically modified organisms (GMOs)[1] has triggered the formation of across-country differences in GMO standards. One reason behind this process is related to the different welfare effects induced by GMOs on different groups of the society (see Lapan and Moschini, 2004; Veyssiere and Giannakas, 2006; Moschini, 2008). Indeed, different GMO regulations may reflect the preferences of the various groups involved in the government decision-making process, like consumers, farmers, and agrochemical and seed companies.

This consideration motivated a growing interest in the political economy of GMO regulation. For example, Anderson *et al*., (2004) investigated the trade and protectionist effect of the GMO regulation of the European Union. Gruère *et al*. (2009), using a proportional voting model, studied the determinants of GMO labeling policies. More recently, Swinnen and Vandemoortele (2011), exploiting the property of the Grossman and Helpman (1994) 'Protection for Sale' model, showed how factors like country comparative advantage and the strength of the main lobbying groups affected the government preferences on GMO standards.

The majority of these studies are theoretical in nature. Until now we lack a comprehensive empirical investigation into the determinants of GMO standards, which exploits the large across-country differences in GMO regulation. Indeed, such regulatory differences are an interesting source of policy variation that needs further explanation. In many rich countries, consumers and green associations are concerned with the safety of new biotechnologies, for both health and the environment, and they have asked governments to adopt regulations to check for any negative potential effects of these products. Other developed countries are cultivating GM crops extensively, and they use GMOs to produce manufactured foods without setting regulations that could restrict GMO diffusion. Developing countries are often in the middle of these two approaches, creating a highly heterogeneous international regulatory framework.

In this paper, we empirically study the determinants of GMO regulation and, to this end, we present a new composite index on GMO regulation across a large cross-

[1] The first commercially grown GM crop was the Flavr Savr tomato of the Calgene Company. It was released on the market in 1994, and its genetic modification consisted in a longer shelf life due to ripening with a low decay rate. However, its diffusion was limited. The first extensive GM crop appeared in 1996, and it was the herbicide-tolerant soybean called Roundup Ready of the Monsanto Company.

section of countries, taking into account the multidimensional nature of the GMO regulation. Next, using this index and its components as dependent variables, we test which factors highlighted by the theoretical literature are important in explaining the restrictiveness in GMO regulation. Importantly, the analysis takes into account the role of the market for information. Indeed, while several papers have stressed the important role played by the media in shaping consumer perception and behavior on food safety standards in general, and on GMOs in particular (see, e.g., Verbeke *et al*., 2000; Kalaitzandonakes *et al*., 2004; Swinnen *et al*. 2005), a formal test on the effects of media markets on the GMO regulatory process is still lacking. Our paper represents a first effort to fill this gap.

The paper is organized as follows. Section 2 presents the structure and strategy in building the composite index on GMO regulation. Section 3 reviews the theoretical literature on the determinants of food standards and GMO regulations. Section 4 presents the data and the econometric strategy. Section 5 provides the results of the empirical analysis and, finally, section 6 concludes.

2. Across-country differences in GMO standards and regulation

2.1 Sample and data sources

To study the GMO regulation determinants it is necessary to compare regulations around the world. However, until now a benchmark index on GMO regulations has been lacking. The first aim of this section is to describe our strategy to construct such an index.

We build the GMO regulatory index for 60 countries, collecting available information on laws and acts ruling GMO cultivation and commercialization. We collected data until June 2008, so that the large fraction of considered GMO standards was in place in 2007, or before. Note that, especially for some developing countries, significant delays in regulation enforcement could have occurred for political and technical reasons. Hence, the relative GMO restrictiveness ranking for some developing countries could be slightly biased up-ward (see below).

Country sample includes most of the EU countries and OECD members, the most important exporters and producers of agricultural goods, and several developing countries. Table 1 lists all the countries. The countries in the sample were selected on the basis of their economic relevance in agricultural international markets, and on sufficient availability of information on GMO regulations.

The main information sources used are Global Agriculture Information Network (GAIN) reports on biotechnology, provided by the Foreign Agricultural Service (FAS) of the United States Department of Agriculture (USDA). For missing information we referred to official national acts and reports.

2.2 Computational strategy

Our GMO regulatory index is built in the same spirit as the Ginarte and Park (1997) intellectual property rights (IPR) index. Six different categories of GMO production and commercialization regulations were taken into account: (1) approval process, (2) risk assessment, (3) labeling, (4) traceability, (5) coexistence, and (6) membership in international agreements on GMOs. Each category was scored with a value ranging from 0 (first condition) to the highest number of conditions identified for the category. Table 2 reports the respective score conditions. Higher scores indicate an increasing restrictiveness of the regulatory dimension. For example, for 'GM-free' countries (where no GMOs can be cultivated or commercialized) the highest score is assumed. In what follows we propose a summary discussion and justification of each regulatory dimension. For a more exhaustive discussion, see Vigani (2010).

2.2.1 Approval process

The approval of a GMO is the basic condition to permit its entrance in the domestic market, both for cultivation and/or for consumption. Without approval, it is not possible to introduce the GM product into the country.

Approval requirements vary widely across countries, but there are two main approaches. One is the EU approach based on the 'precautionary principle', which states that any product produced with, or derived from, transgenic crops is subject to specific regulations and the consumer's 'right to know'. The second is the US attitude of 'substantial equivalence', which exempts essentially equivalent products from any specific requirements (Gruére, 2006). Lying between these two extremes there are further approaches to approval.

We defined five levels of restrictiveness (from 0 to 4) based on the country's approach and on the degree of implementation of the regulation. A score of 0 is given when there are no approval procedures; a score of 1 if the legislator decided for a mandatory approval process, but it is not yet enforced; a score of 2 when the mandatory approval process follows the principle of substantial equivalence; a score of 3 when the mandatory approval process follows the precautionary principle; a score of 4 for GM-free countries. The zero and first conditions include developing and emerging countries that tend to take advantage of the absence of a defined regulation, adopting the so called "wait and see" strategy. By not taking a clear position with respect to the approaches of the EU (more restrictive) and US (less restrictive), the countries remain open to both markets.

2.2.2 Risk assessment

Approval depends on a positive risk assessment, which consists in the analysis of potential harmful effects of the new organism on humans, animals and the environment. The typology of the tests depends on the country approach, whether it is based on the substantial equivalent or the precautionary principle.

Biosafety assessment is progressively gaining importance as it is the target for setting a common international methodology, but discussions and bargaining are still in progress. Countries possessing native plants need tests for potential gene flow from GM crops to their wild (native) relatives. Biosafety assessment requires expensive field trial programs, and some countries (e.g. developing countries) are not able to deal with these costs.

We identified four requirement levels (range 0-3). Both conditions 0 and 3 indicate the absence of risk assessment, but, whereas 0 indicates a normative void that does not affect GMOs trade or cultivation (e.g. Ukraine), condition 3 is applied to GM-free countries that do not require any risk assessment as the importation and cultivation of GMOs are *a priori* banned. Between these two extreme situations, a score of 1 is assigned when the risk assessment is at the proposal stage, while a score of 2 is for when risk assessment is compulsory.

2.2.3 Labeling

According to the threshold level, labeling directly informs on the presence of GM ingredients in the product, but indirectly a label can also act as a hazard warning, affecting the demand for GM and non-GM products (Gruère, 2006).

There is a wide variety of different labeling regimes across countries, and these differences are mainly due to production, development and trade related factors.

Developed and less agriculture-dependent countries are more likely to adopt GM labeling regimes, due to consumer demand for food information. Differently, developing countries are more exposed to regional influences and trade relationships. Moreover, countries producing or exporting GM products tend to adopt more pragmatic and less costly labeling policies. Such costs depend on the threshold level, on the capacity of the public authority to enforce labeling requirements, and on the capacity of the industry to comply with labeling rules. Hence, to comply with a restrictive threshold implies more onerous costs.

Countries may decide to adopt voluntary or mandatory labeling. Labels can be on the finished product (Australia and Japan), and/or on GM technology as a production process (EU and China). In the former case, the quantification of GM ingredients is required, and, usually, the threshold is higher. In the latter case any product derived from GM crops must be reported. In this case thresholds are lower.

We identified five categories of labeling (0-4): 0 in the absence of labeling; 1 with voluntary regime; 2 with mandatory regime and threshold higher than 1%; 3 with mandatory regime and threshold equal or lower than 1%. Finally, 4 is assigned to GM-free countries.

2.2.4 Traceability

Traceability is an instrument used by some countries to guarantee efficient GMO product withdrawal from the food and feed market if any unexpected effect occurs to health and the environment. It involves all the actors of the food chain, retracing the history, use, and location of a product by means of recorded identification.

Farmers must comply with certified storage and harvesting, while elevators, operators and retailers must keep information on product identity and transmit it by lot numbers. This information must be retained for a long period (5 years post-market monitoring), and must be available for applicants. All these requirements induce increasing costs sustained by the production and supply chain, but also benefit the market niche gains.

For traceability we defined the following scores: 0 if the regulation does not require traceability or identity preservation (IP); 1 if the traceability requirement is at the proposal stage or if an IP system is implemented; 2 if traceability is mandatory; and 3 if the country is GM-free.

2.2.5 Coexistence

The purpose of coexistence is to guarantee consumers and farmers the possibility of choice between GM, traditional and organic products. Coexistence is based on IP among crops, which must be segregated in time and space. Thus, it is not possible to cultivate contiguous fields of GM and organic crops, or to manage such crops in short rotations. In addition, coexistence may require mechanisms preventing pollen flow (such as distance or pollen barriers), as well as refuge areas and dedicated machinery. Of the utmost importance are the cooperation between neighboring farmers and compensation and liability schemes.

Production costs increase due to the isolation, monitoring, purity testing, and dedicated equipment. The affordability of coexistence is related to the level of development of the country. In developing countries some policy makers take for granted that coexistence is not feasible or can be done only by facing prohibitive costs.

Policy makers face great difficulties in setting up coexistence strategies, given the divergent preferences of organic and GM producers. Typically, organic producers and consumer groups lobby against the authorization of GMO cultivation, and hence ask for very restrictive coexistence regulations (e.g. extremely long distances between fields), impeding *de facto* the cultivation of GM crops.

We decided to score with 0 those countries without any coexistence rule; 1 if coexistence policies are still far from enforcement (e.g. the government decided on the need of coexistence policies, but field guidelines are still under discussion); 2 if partial guidelines were prepared; 3 if exhaustive coexistence guidelines are adopted; and 4 if the country is GM free. We could not exploit distances in score definition because of the lack of information for all the countries.

2.2.6 Membership in the international agreements

We considered two main agreements, the Codex Alimentarius and the Cartagena Protocol on Biosafety, which are the most diffused and developed agreements on GMOs.

The purpose of the Codex Alimentarius is to define international standards to protect consumer health and promote fair relationship in trade practices. It has successfully reached an agreement on safety assessment procedures for GMOs, but no formal labeling standard has been yet achieved.

The Cartagena Protocol on Biosafety (BSP) is part of the United Nations Convention on Biodiversity, and it introduced a procedure for risk assessment, risk management and trans-boundary movements of living modified organisms (LMOs). The BSP requires a comprehensive risk assessment and risk management framework provided by the exporter before the introduction of any LMO in the importer territory. The BSP was proposed as a primary policy for those countries without domestic regulations on GMOs and to protect countries holding most of the global biodiversity, typically located in the south of the world. To comply with BSP requirements is costly, and developing countries could benefit from collective funds provided by the agreement.

If a country does not adhere to either of the two agreements the score is 0, otherwise the score is 1 or 2 when subscribing to one agreement or both, respectively.

2.3 The GMO regulatory index and its components: Stylized facts

The overall GMO index is obtained by the unweighted sum of the scores of the six categories described above.[2] After normalization, the final GMO index takes values between 0 and 1. Higher values indicate a more complex regulation that suggests a higher restrictiveness in GMO cultivation and commercialization.

Table 1 provides the list of countries covered, and their respective GMO index. None of the countries in the sample have a GMO index equal to 0. Indeed none totally ignore the need to regulate GMOs. For example, in Hong Kong, which has the lower restrictiveness in GMO regulation (equal to 0.10), the introduction of a risk assessment procedure has been proposed, and a voluntary labeling regime is enforced.

Several interesting patterns emerge from Table 1. First, we observe the expected polarization of the two leading countries in GMO regulatory setting: the US and the EU. The former has a GMO index of 0.35, in contrast with the EU average of 0.69. Second, with the exception of the two GM-free countries Zambia and Zimbabwe, developing countries tend to be in the low part of the ranking. In contrast, OECD countries are uniformly distributed throughout the ranking.

[2] The possibility of assigning a different weight to the categories has been considered. Nevertheless, the absence of a theory on how to distribute the different weights led to the option of accepting a uniform degree of category importance.

Third, in addition to the EU, other major agri-food importers like Japan (but not South Korea) have a relative restrictive GMO regulation, while major exporters (e.g. Argentina, Brazil, Canada and Ukraine) have a "soft" regulation according to their comparative advantage in the production of agricultural products. Finally, within the EU countries there is a certain degree of heterogeneity. The highest score (0.75) was found for countries like Austria and Italy that have imposed a *de facto* ban on the cultivation of GM maize approved by the European Commission. Moreover, the majority of Italian and Austrian regions are members of the European GMO-free Regions Network. In contrast, Spain and Germany have significantly lower scores, equal to 0.60 and 0.65, respectively. At the time of the data collection, both countries had less restrictive regulation. To date, Spanish GMO regulation is almost unchanged and GM maize is still cultivated. In contrast, in the last few years Germany's regulation has become increasingly restrictive, including on GMOs cultivation. The index does not reflect the changes occurred in Germany because built on earlier information of 2008.

Table 3 provides the summary statistics and correlation matrix of the index and its components. First, and not surprisingly, some categories are strongly related to each other, i.e. in many regulations an approval process cannot be conducted without risk assessment. The strongest correlation is between labeling and approval process; traceability and labeling and coexistence and traceability. However, what is interesting to stress here is that the correlation coefficients across components are often lower than 0.50, suggesting that they add substantial information to the overall index.

2.4 Statutory and factual restrictiveness in GMO regulation

One important aspect in dealing with regulation is the discrepancy that often exists between written laws and how they are actually applied. To calculate the index, we decided to exclusively use written GMO regulations as source of information. This permits to reduce at minimum the subjectivity bias, but we are aware that regulation enforcement may vary.[3] Because factual laws are the ones that have a concrete effect

[3] We decided not to account for information on the functionality of regulatory systems, because this information mainly come from potentially biased sources, such as newspapers, green organization, biotech companies, etc. For example, India provides a full portfolio of acts ruling production and commercialization of GM crops and derived products, but its regulatory system is highly dysfunctional, affecting laws enforcement. Information on the functionality of the Indian GMOs

on consumers, production and trade, in this section we discuss some examples of the differences between statutory and factual GMO regulations.

In general, lack of regulation implies a great degree of uncertainty which may prevents field trialing, production and/or importation of GMOs and a number of developing countries are subject to such condition. Furthermore, in many cases lack of regulation is a transitory state which can turn into a very restrictive regulatory environment as soon as the transition period ends. For instance, according to regulation until 2008, Peru and Turkey are ranked by the GMO index as two countries with the least restrictive regulatory environments in the world. Yet, Turkey has recently installed one of the most onerous biotech regulations and Peru has been legislating itself into a GM-free country. The GMO index does not have a time variation, hence, unfortunately, we are not able to capture these effects.[4]

Moreover, some developing countries do not have clearly defined GMO regulations. For example, in Mexico and Vietnam the labeling of GMO ingredients is compulsory, but no labeling threshold is defined and not well specified exemptions are permitted. A lack in the labeling threshold can represent a factual ban on GMO imports induced by control organisms that, in the attempt to avoid testing ambiguity, react with an overall rejection of products containing GMOs, but we do not have objective proof of the ban. On the contrary, comprehensive regulation provisions, despite rather streamlined and not particularly complex, may lead to an overestimation of the stringency. Regulations that specify minimum threshold content permit GMO imports, even though the threshold is very restrictive. As a result, it is more likely to overestimate GMO regulation restrictiveness in those countries where regulations are well documented and comprehensive, such as OECD or EU countries (e.g. the Netherlands and Portugal).

Another important aspect affecting regulation decisions are the international trade rules. Following WTO agreements, it is not possible to discriminate imported products from domestic ones. Policymakers must comply with WTO rules but, at the

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regulatory system comes from not-official highly-subjective sources. Because we rely exclusively on written laws, and this does not permit to register the level of functionality of the Indian regulatory system, the Indian position in the index ranking may appear biased, but it reflects what is included in the Indian law's requirements.

[4] To date, no major changes occurred in the GMO regulations of the countries analysed, in particular in the European Member States and other important countries such as the US. It is necessary to wait some more years to achieve sufficient heterogeneity allowing updating the GMO index.

same time, they are interested in maintaining the voters' confidence, taking into account domestic consumers and producers preferences. Hence, despite statutory regulations permitting GMO commercialization and cultivation, in some countries GMOs are factually not cultivable or tradable because of domestic public opinion preferences. For example, the EU provides Member States (MS) with directives that must be enforced by national laws, and that comply with WTO rules. But the way the single MS translates the directive by mean of national law creates the factual rule.

Extremely important for the effective cultivation of GM crops in the EU is the approval of coexistence protocols. Despite GM maize have been approved for cultivation in the EU, only 5 countries (Czech Republic, Portugal, Romania, Slovakia and Spain) out of 27 are producing GM maize (James, 2012). The absence of approved coexistence protocols at the national level was one of the major reasons supporting the prohibition of GMO cultivation. Without coexistence measures it is not possible to guarantee consumers and producers the choice between GM, traditional and organic products, but at the same time the approval of these measures allow farmers to cultivate GM crops. If the approval of coexistence measures is delayed or blocked, GM cultivation is *de facto* impeded. Hence, in several MS, it took many years to issue coexistence protocols despite the European Commission required each MS to provide protocols in 2003 with Recommendation 2003/556/EC.

3. Determinants of GMO standards: theoretical considerations

The purpose of this section is to identify those factors that the theoretical literature indicates as key determinants of GM regulations and standards. Government policies depend on several factors that drive stakeholders' preferences and the political equilibrium. But it is not only the internal characteristics of a country that matter in standards formation. There are also important exogenous factors that influence policy decision, such as trade relations in general and regional trade agreements (RTA) in particular.

The theoretical literature emphasized some of these factors through different approaches. Some authors explained GMO standards formation mainly as a function of trade interests. For example, Tothova and Oehmke (2004) developed a Krugman-style trade model (Krugman, 1979) that showed that countries select standards taking into account enforcement costs, loss of productivity and loss of trade. Particularly relevant in our context is the two-country partial-equilibrium model developed by

Lapan and Moschini (2004) to capture international trade implications of GM technology adoption. In the model, the factors that influence GMO regulation are compliance costs, consumer preferences, income level, and differences in price between GM and GM-free products. The authors showed that the introduction into the market of GM products may lower welfare due to costs associated with the regulation, but, at the same time, the regulation may redistribute income among trading partners, and may benefit importing countries.

Given the rent distribution associated with the adoption of GMOs, a political economy perspective that allows for interest groups to explain standards formation appears to be an essential ingredient to analyze the determinants of standards. For example, Fulton and Giannakas (2004) showed that the political equilibrium depends on the efficiency in producing pressure among three lobbying groups (consumers, producers and companies) that compete for different policy outcomes under labeling and no labeling regimes, and also in absence of GM products. Consumers' welfare is reduced when there is aversion to GM products and IP costs are high, and producers' welfare is reduced when consumer aversion and GM seed costs are high. Companies' preferences are driven by profit maximization, depending on demand for GM seeds and company market power. Gruère *et al*. (2009) developed a proportional voting model where labeling policies are decided under the influence of pressure from producers, green party and voters. They pointed out that production and trade related interests play a dominant role in the choice of labeling policies. Vandemoortele (2011) developed a dynamic model of government decision making on technology regulation and standard that illustrates that differences in GM regulation between the US and the EU are driven by consumer preferences and protectionist purposes.

3.1 Optimal standards formation and the role of the mass media

The political economy model that better describes GMO standards formation is the model of optimal public standards formation developed by Swinnen and Vandemoortele (2011), and extended in Vandemoortele (2011). This model is based on the Grossman and Helpmann (1994) theory that explains trade policies formation as an equilibrium outcome of the activity of special interest groups. These groups make political contributions in order to influence government decision making. From this model it is possible to derive some predictions about the relevant factors affecting the stringency of standards.

Swinnen and Vandemoortele (2011) considered two active lobbying groups, namely producers and consumers. Both groups are politically organized to lobby in favor of the preferred standard. In an open economy, the standard benefits consumers because it guarantees the preferred quality characteristics of the product, while producers' production costs rise in implementing the public standard. Producers and consumers may lose or gain in the presence of the public standard, hence their contribution in favor of a certain standard level depends on the marginal effect of the standard on producers' profit and on the marginal change in consumer surplus.

Formally, the model defines domestic welfare, *W*, as the sum of producer profits, Π_p, and consumer surplus Π_c:

(1) $$W(s) = \Pi_p(s) + \Pi_c(s)$$

The optimal standard level corresponds to the optimal standard for the government. The optimum for the government is given by the sum of groups' contributions, C_i, and total domestic welfare. Hence, the government maximizes its objective function, that is:

(2) $$V(s) = \alpha_p C_p(s) + \alpha_c C_c(s) + W(s)$$

where, α_p and α_c are coefficients of lobbying strength of producer and consumer organizations, respectively. The government will choose that level of the standard that maximizes its objective function. Contributions (C_i) are optimal when producer profit and consumer surplus are maximized. As a result, the government will choose that standard which maximizes producer profit and consumer surplus to obtain the maximal contributions.

The effect of the standard on producer profit and consumer surplus may be positive or negative. If the marginal unit cost increase is larger than the marginal price effect in the presence of the standard, the producers' profit decreases with an increase of the standard, *vice versa* the producer gains from an increase of the standard. If the marginal consumption effect exceeds the marginal increase in costs of consumption, the aggregate consumer surplus increases with the standard, *vice versa* the aggregate consumer surplus decreases with the standard.

The optimal standard level is a function of several variables, namely the lobbying strength of pressure groups (α_p and α_c), consumers' preferences, products' price with and without the standard, and production and transaction costs.[5]

Swinnen and Vandemoortele (2011) analyzed two further important determinants of food standards, namely trade and comparative advantage. With larger imports ($m \equiv c - q$) and lower domestic production (q) the effect of a standard on producer profit is smaller. Consequently producer contribution (influence) on government decision is smaller. More imports and higher consumption (c) increase the aggregate consumer surplus, hence the consumers' lobbying activity increases. Note that, if domestic production is extremely small or absent (q = 0), producers do not engage in any lobbying activity, and only consumer interest affects the government policy outcome. These findings are consistent with both Tothova and Oehmke (2004) and Lapan and Moschini (2004). Moreover, standards can affect both production and transaction costs. If producers have a comparative disadvantage in standardized good production, they will oppose standards reducing political contribution. But there might be an opposite effect. Importer countries with higher production costs may be more efficient in complying with the standard, hence this comparative cost advantage in transaction costs encourages national producers to contribute in favour of the standard, reducing foreign country export opportunities.

Vandemoortele (2011) provides an important extension of the model of Swinnen and Vandemoortele (2011). The author includes the effect of a biased perception of the standard. This bias affects standard preference due to the level of consumer information, where the primary source of information is the media. Hence, the media greatly contributes to forming consumer attitudes on standards.

Several papers have highlighted the important role played by the media market in shaping consumer perception and behavior on food safety standards (see, e.g., Verbeke *et al*. 2000; Swinnen *et al*. 2005; Kalaitzandonakes *et al*. 2004).

A small but growing literature has recently formalized the behavior of the media into a political economy structure (see Prat and Strömberg, 2011, for a recent survey). Strömberg (2004), in his model of mass media and political competition, highlights a media bias to deliver news toward large groups and groups more

[5] A change in consumer preferences affects aggregate demand and consumer surplus. Higher consumer preferences result in higher consumer surplus, hence in higher contribution for the preferred public standard. On the other side, higher marginal unit costs reduce the benefit of the standard for the producer, which will reduce the contribution for the public standard.

valuable to advertisers, increasing voter awareness and response to political actions.[6] At the same time, Prat and Strömberg (2005) showed that a shift from state-control to private-control of TV news, increases voter information and political participation.

Building on these predictions, Olper and Swinnen (2013) studied the implications for agricultural and food policies. These implications can be extended also to food standards. The starting point is that in agricultural and food markets, government policies are biased in favor of urban consumers' interests in poor countries and farmers' interests in rich countries. Moreover, according to Prat and Strömberg (2005), an increase in the share of commercial media (*vis-a-vis* state controlled media) should increase the information available and the political participation of (large) groups of consumers who, under the mass media state monopoly, had less information. This suggests that the restrictiveness of food standards in developed countries might also be related to the structure of the media market (private *vs.* state media). Indeed, commercial TV and radio stations, as well as written press, are now the dominant players of the media market in both Europe and other developed countries (Swinnen and Francken, 2006).

An important consideration to understand different consumer attitudes on GMOs between developed and developing countries is provided by Curtis *et al*. (2008). Following the theoretical approach of McCluskey and Swinnen (2004), they suggest that consumers' risk perception associated to GMO is lower in developing countries, due to the more difficult access to media and less leisure time availability with respect to developed countries. Both factors increase the costs of media consumption.

Building on this intuition, Vandemoortele (2011) goes further, showing that in developing countries the relative higher cost of media access leads to lower media consumption. Consequently, reported risks are proportionally less in poor countries than in rich ones. Thus, the media structure in rich countries increases attention to risk, promoting consumer preferences in favour of the standard.

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[6] Strömberg argues that if more informed voters receive favorable policies, then mass media should indirectly influence policy formation because it provides most of the information used by people in voting.

4. Empirical specification, data and econometric issues

4.1 Empirical specification

On the basis of the theoretical background presented in section 3, we selected four different groups of potential explanatory variables of GMO regulations: trade and comparative advantage, structural determinants, institutions, and the media market. All the data used for the explanatory variables predate the GMO index to reduce potential endogeneity bias. Table 4 provides summary statistics and year of the data, while Table 5 provides correlations between explanatory variables.

In the first group "Trade and comparative advantage" we include three variables. The first is the export share of agri-food products on total exports in two relevant markets, the EU and Japan as an aggregate (*EU-JPN Export share*). We selected these markets because they are net importers of agri-food products and also because the safety of GM products is a sensitive issue for consumers in both countries (Grueré, 2006). GMO standards are restrictive in both the EU and Japan, and it is expected that countries interested in trading with them will satisfy European and Japanese consumers' demand for safety. In order to avoid simultaneity bias, this variable is measured prior to the introduction of GMOs on the market place in 1996. Trade data are taken from the UN COMTRADE database, through the World Integrated Trade Solution (WITS) service provided by the World Bank. Second, we controlled for the (applied) level of tariff protection (*Applied tariff*). The rational is the following: several authors (Fischer and Serra, 2000; Anderson and Jackson, 2004; Sturm, 2006) have stressed that standards may act as substitutes of tariffs in protecting the internal market through complex and costly regulatory requirements.[7] If this hypothesis holds, the GMO regulation should be negatively related to the level of tariffs, *ceteris paribus*. Following Olper and Raimondi (2008), we used a trade weighted average of the 2004 applied tariffs related to agricultural products, provided by the Market Access Map (MAcMap) database (Bouet *et al*., 2008) jointly developed by ITC (UNCTAD-WTO) and CEPII. The third variable is land per capita (*Land pc*), which represents a factor endowment ratio affecting agricultural comparative advantage (Anderson *et al*. 2004). Data of land per capita comes from the World Bank, WDI database.

[7] However, note that the fact that standards and, more in general, NTBs may act as a substitute/complement for tariffs trade protection, still represents an empirical question.

The second group of variables are the "structural determinants". First, we used the percentage of organic acreage (*Organic*). Due to the green campaigns of non-governmental organizations (NGOs) and green parties, GM and organic products have become representative of opposite conception of agricultural activity. On the one hand, GMO cultivation represents intensive agriculture characterized by high use of inputs (chemicals, pesticides, fuel and so on), on the other hand, organic production represents a sustainable and environmental friendly agriculture. A high percentage of organic crops can reflects producer and consumer demand for sustainable agriculture, hence a greater demand for stringent GMOs standards. Data on the percentage of organic acreages are taken from Willer and Yussefi (2000). Moreover, to control for the strength of agricultural lobbies we include the share of agricultural labour (*Rural population*). As is well known, small farm groups increase the effectiveness of the farmers' lobby (Olson, 1985; Olper, 2007). However, as a high percentage of employees in agriculture can affect the weight of producers in the political decision-making process through the voters' channel, a (possible) no-monotonic relationship is considered, introducing the variables both linearly and squared (*Rural population sq*). The data on agricultural and non-agricultural labour come from the World Bank's WDI database.

The third group of variables, 'Institutions', contains the Polity2 index of democracy taken from the Polity IV data base. Polity 2 varies from -10 (worse autocracy) to +10 (better democracy). We converted the index to a scale from 0 (autocracy) to 20 (democracy), where higher values are associated with better democracies. Countries based on a democratic political system provide greater representation of the population and different interests, hence policymakers take into account the citizens' preferences in regulation setting. We also control for an index of the environmental regulatory regime (*Erri*) developed by Esty and Porter (2001). The *Erri* is a composite index on the quality of environmental regulation ranging from 0 to 4, where higher values indicate a higher regulatory quality. This index is built combining several aspects of the environmental regulatory regime (stringency, structure, subsidies, enforcement and environmental institutions). Due to the implications of the environmental release of GMOs, countries with greater demand for environmental quality may also increase the complexity of GMO regulation. Finally, within this variables group, we also include a proxy for the impact of legal contributions to political parties on public policy outcome (*Lobby*). We took the

Lobby variable from the DataGob database developed by the Inter-American Development Bank (IADB). This variable is built starting from surveys on business executives, asking answers to the following question: "To what extent do legal contributions to political parties have a direct influence on specific public policy outcomes?". Thus, this variable represents a proxy of the extent to which the lobbying activity translates into government policy outcome. *Lobby* variables range between 1 (very close link between donations and policy) and 7 (little direct influence on policy). We converted the index to obtain an opposite value, so that the index still ranges between 1 and 7, but it increases in the link between lobby contributions and policy outcome.

In a previous section we already discussed the (potential) important role of the media's structure in determining GMO regulation. The objectives of private and public media are significantly different. Private ones tend to be more consumers oriented, and provide information in such a way as to increase media consumption. Food scares are of great interest for consumers and may contribute to increase the demand for media information. In this context, the GMO debate is delivered from an awareness point of view by privately controlled media. As a result, the way private media does business can induce consumers to ask governments for more restrictive GMO standards. On the contrary, public-controlled media are more government oriented, and will satisfy policies preferred by organized groups with greater lobbying power. Farmer groups are typically well organized, and it is likely that they will lobby in favour of cost-saving high-productive innovations (i.e. GMOs).

Moreover, for several reasons, the effect of the media market on GMO standards may be conditional to the level of development. First, the level of economic development affects the media structure. In most of the developing countries public controlled media strongly prevails, while in rich countries media market structure is highly fragmented. In these countries a greater share of the news is delivered by different private media companies (press and TV) in strong competition. Second, as discussed above, the level of development also affects the target group of private media (see Olper and Swinnen, 2013). In developing countries, the target group tends to be the farmers group, whereas in developed countries the target is the consumers group. To test these predictions, we used the share of the private media computed as an average between private press and TVs both linearly (*Private media*) and interacted with the GDP *per-capita,* (*LnGDPpc*Private media*). Data on the share of private TVs and newspapers are taken from Djankov *et al*. (2003).

Finally, the last variable is the log of *per-capita* GDP in PPP (*LnGDPpc*) taken from the World Bank's WDI. The Level of development has several regulatory implications. For example, on the one hand some requirements are costly and for least developed countries their enforcement is burdensome, due to high transaction costs. On the other hand, it is well known that the demand for food safety regulation is elastic to the income level.

In the analysis we considered 55 countries for which all the explanatory variables discussed above were available.[8] The general specification that links the GMO regulation and its potential determinants is shown in the following equation:

$$(3) \quad GMO_i = \beta_0 + \beta_1\, Export\ share + \beta_2\, Applied\ tariff + \beta_3\, Land\ pc + \beta_4\, Organic + \beta_5\, Rural\ population + \beta_6\, Rural\ population\ sq + \beta_7\, Polity2 + \beta_8\, ERRI + \beta_9\, Lobby + \beta_{10}\, Private\ media + \beta_{11}\, Ln\ GDPpc*Private\ media + \beta_{12}\, ln\ GDPpc + \varepsilon_i,$$

Where, GMO_i is the GMO index of country *i*, β_0 is a common intercept, $\beta_1 - \beta_{12}$ are the coefficients to be estimated, and ε_i is an error term.

4.2 Econometric issues

A main concern in estimating equation (3) can derive from spatial correlation issues. In fact, regulations of countries that are spatially closed are potentially correlated due to the existence of regional trade agreements signed by neighbouring countries or other omitted factors. To tackle with this problem we use different strategies.

First, the equation (3) is estimated using OLS. Subsequently, the same specification is estimated including regional dummies (for Asia, Latin America, North America, Oceania, Middle East and the EU countries) to control for the specificity of regional agreements in terms of GMO regulations, trade and economic integration.

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[8] Specifically, the lobby variable from the DataGob database is not available for Denmark, Germany, Guatemala and Saudi Arabia, while the WDI database does not provide the rural population for Taiwan.

Second, we directly tackle the issue by testing for the presence of spatial autocorrelation in the error term, using the Moran's I index.[9] This index expresses the degree of similarity between spatially close countries with respect to the error term (Pfeier *et al.* 2008) and it detects the general tendency to clustering across countries. If the computed index is statistically different from its expected value, than we cannot reject the null hypothesis of zero spatial autocorrelation in the residuals.

Third, regression (3) is estimated also using spatial regression[10] to estimate the relationship between the GMO_i variable with the predictors X_j with j=12, taking into proper account the spatial autoregressive process in the error term. The spatial dependence is represented by the following spatial error model:

$$GMO_i = X_j\hat{\beta} + \lambda W\xi + \varepsilon$$

Where X_j is the matrix of explanatory variables; $\hat{\beta}$ is the vector of estimated coefficients; λ is the spatial autoregressive parameter; $\boldsymbol{W}$ is the spatial weight matrix of distances between countries (see Mayer and Zignago, 2011); ξ is a vector of spatial errors, and finally ε is the uncorrelated errors term.

5. Results and discussion

5.1 Determinants of GMO regulation restrictiveness

Table 6 shows the regression results of different specifications based on equation (3), considering the determinants of the overall GMO regulatory index. Column (1) provides results from a standard OLS regression, while column (2) adds a set of regional fixed effects. Differently, in column (3) we use the spatial regression approach discussed above, with maximum likelihood estimator. The results from the three specifications are consistent, all the covariates have the expected sign and significance is quite similar across specifications.[11]

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[9] The Moran's *I* test is implemented in STATA, using the command *spatgsa* (see Pisati, 2001).

[10] For the spatial regression we used the STATA written command *spatreg* with maximum likelihood estimator developed by Pisati (2001).

[11] Because of the potential *de jure* and *de facto* issues discussed in section 2.4, we checked the robustness of our specifications by excluding from the sample those countries that are potentially more affected by such problems, namely India, the Netherlands and Portugal. We did several

At the bottom of Table 6 we report the Moran's *I* test, testing whether the error terms are spatially autocorrelated. All the tests in columns 1, 2 and 3 are insignificant, meaning that in each specification the absence of spatial correlation in the residuals cannot be rejected, and hence errors are not spatially autocorrelated. However, the *p*-value of the Morans's *I* test in column 3 increase significantly, suggesting a greater robustness of the estimation of the standard errors. For this reason, in the remainder of the section and in the next section discussion will focus especially on spatial regressions results.

Overall, the explanatory power of the model appears particularly high for a cross-country regression. Indeed, about two thirds of the variability in the GMO restrictiveness is explained by the selected covariates. Many of the hypotheses discussed above appear largely confirmed. The majority of the variables selected on the basis of the theory are indeed of the expected sign and, many of them, are statistically significant.

Starting from trade and comparative advantage variables, all of them are of the expected sign. The relation between export share and GMO regulation is always positive, although its significance level is quite low when regional heterogeneity is controlled for. In accordance with the GMO index values of Table 1, these two markets have restrictive GMO standards (equal to 0.69 and 0.70 for the EU and Japan, respectively). This result tends to suggest that, *ceteris paribus*, the main trading partners of the EU and Japan that commercialize in agri-food products, also set GMO standards in order to have access to these markets. This result appears in line with the previous findings of Vigani *et al*. (2012), who showed that similar (harmonized) GMO standards increase bilateral trade flows. Moreover, the finding that when correcting for spatial autocorrelation the effect of the export share is no longer significant, suggests that regional influences explain a large part of the effects of trade on the GMO regulation.

The effect of comparative advantage in agriculture, *Land pc*, on the restrictiveness of GMO standards is, as expected, negative in every specification,

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robustness checks. First, we excluded just one country at a time and all the three simultaneously. Second, we tested both the specifications with and without the regional fixed effects. Finally, we did these checks both for the OLS and the Spatial ML estimator. Results of the robustness checks are fully consistent with the results using the full sample of countries, suggesting that potential biases in the index ranking do not affect the structural relationships in the empirical model. Results of the robustness checks are available upon request to the authors.

although its estimated coefficient is significant only in column 2. This result gives some support to the idea that countries with a comparative advantage in agricultural goods are less interested in increasing GMO standards. The compliance with standards induces an increase in production costs, so countries with a comparative advantage try to keep these costs low (or aim to increase productivity through innovative technologies) in order to maintain their comparative advantage with respect to net-importers.

Quite surprisingly, the degree of tariff protection is not significant. The popular view is that tariffs are negatively related to the GMO regulation, as many of the standards in the literature tend to be viewed as instruments of ‘protection in disguise’ to replace tariffs, but, at the overall level, we did not find any evidence of a substitution effect between standards and traditional border protection. However, as we will show in the next section, at the components level they have an important role.

With regard to the agriculture structure variables, the share of *Organic* land has a positive but not significant coefficient, while the significant effect of *Rural population* confirms the presence of a non-linear relationship, namely the linear term is significantly positive and the square term significantly negative. This pattern is consistent with the idea that there exists a trade-off between the strength of the farm lobby due to group size and the importance of votes.

Among the institutional variables, the *Polity2* index is not significant, suggesting that the quality of the democracy is not an important determinant of GMO regulation, after controlling for the level of development. Differently, the quality of environmental regulation (*Erri*) plays a significant role. It is not surprising that more complex and restrictive environmental regimes also induce more restrictive GMO regulations. Consumer reticence on GMOs is not only due to GM food safety concerns, but also to the environmental impact of GM crops. If the government considers the environment to be an important public good, and consumers are demanding environmental protection, then the two regulations (GMO and environmental regulations) may go hand in hand in the same direction.

The significant result for the *Lobby* variable is in line with the theoretical findings of Gruere *et al*. (2009) and Swinnen and Vandemoortele (2011), confirming the importance of the lobbying activity on the politically optimal standard level. The *Lobby* variable captures the link between the donations to political parties and the government decisions, hence our result suggests that in countries where this link is stronger, the GMO regulation is more restrictive. This can suggests that the lobbies that are more effective in their activity are those in favour of restrictive GMO standards, such as green organizations or associations of organic producers.

Next, considering results of the media variables, the linear term of the share of private media exerts a negative effect on the GMO regulation. Differently, the coefficient of the interaction term with the income level is positive and strongly significant. This non-linear or conditional relationship suggests that at lower income levels a larger share of private media induces less restrictive GMO standards. However, when a certain level of development is reached, a larger share of private media induces a more restrictive GMO regulation.[12] This result is consistent with the idea that consumers in rich countries tend to be biased against GMOs because, on average, they are informed by private media that have incentives to deliver 'bad news' stories due to profit maximizing motives. Hence consumers will ask for greater food safety, affecting government decisions in the direction of more restrictive standards. The relationship in poor countries changes from positive to negative because, in this situation, the target group of the media outlet are farmers and not consumers, the former being relatively larger in number. Quantitatively, increasing the share of private media from 0.6 to 0.8 (corresponding to about one standard deviation, or an increase of 33%), increase the GMO index of rich countries of about 13%, and decrease the GMO index of poor countries of about 25%, ceteris paribus.[13]

The interpretation of the results on the media variables is in line with the hypotheses developed in Olper and Swinnen (2013) and based on the Stromberg theory (2004), which suggests that media competition induces a bias toward those

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[12] The marginal effect of the media variable is $\frac{\partial GMO_i}{\partial Media} = \beta_{10} + \beta_{11} * LnGDPpc$. Thus, the sign of the derivative depends on the level of development. Using results from column (3) of Table 6, the level of *GDPpc* where the relationship change signis equal to 9.13 ($LnGDPpc = -\frac{\beta_{10}}{\beta_{11}} = 9.13$), that is very much closed to the median value of the distribution (8.83). Thus, for countries with a *GDPpc* lower than 9,230 US $ (= *exp* (9.13)), the marginal effect is negative. Differently, for an income level higher than this threshold, the marginal effect is positive.

[13] The magnitude of these estimated effects is measured considering one standard deviation above and below the mean of the GDP per capita. Using the lower and higher GDP per capita of the sample, the magnitude of the estimated effects, clearly increase.

policies that satisfy the larger group of voters because large groups are the most informed, since mass media target them. Given that in developed countries the farm group is typically small, while in (agriculture-based) developing economies the farm group is relatively large, then private media should promote agricultural policies that favour the farmers in developing countries, rather than those in developed countries, *ceteris paribus*.[14] The media effect is not only significant, but it also gives a substantial contribution to the explanatory power of the model. To give an idea of the effect we also ran a regression excluding the media variables. *R*-squared significantly decreases, passing from 0.843 (Table 6, column 2) to 0.720, suggesting that the media variables alone, account for about 15% of the model explanatory power, thus a relevant fraction.[15]

5.2 Determinants of GMO regulatory components

As mentioned earlier, we also ran equation (1) using each of the six components of the GMO index as a dependent variable. Results of the spatial regression specification correcting for spatial autocorrelation are reported in Table 7, and this section will summarize the main findings.[16]

Applied tariffs has a positive and significant effect on the restrictiveness of the approval procedures, suggesting complementarities between this specific standard and traditional protection instruments. However, the level of tariff protection turns out to be negative when labelling, traceability and coexistence requirements are taken into account (see columns 3, 4 and 5). The opposite effect of tariff on the different components (positive on approval process, risk assessment and international agreement, but negative on labelling, traceability and coexistence) appears perfectly in line with the weak effect detected at the aggregate level (see Tab. 6). The negative and significant effect of tariffs on traceability and coexistence suggests substitution rather than complementary effect of these measures with respect to tariffs. Hence, reading this result from a trade protectionism perspective, it appears that different

[14] Indeed most of the developing countries in our sample are ranked with a low GMO index, resulting in less constraint in the adoption of GMO.

[15] Using the standardized β coefficients we reach the same conclusion, the media variables are by far the most important explanatory variables of the empirical model.

[16] Despite the correction with the Spatial ML estimator, we cannot accept the hypothesis that there is no autocorrelation in the residuals of columns 2 and 4 of Table 7.

component of the GMO regulation can be used for different purposes for trade policies.

The *Rural population* is the most important structural variable affecting the components of the regulation, with the exception of coexistence. Also at the components level the not linear effect of this variable is confirmed.

Only two of the three variables capturing institutional dimensions exert a significant effect, *Erri* and *Lobby*. Indeed, *Erri* is a significant determinant of the approval process, the risk assessment, traceability and international agreements, suggesting that these components are directly linked to the domestic regulatory regime. Moreover, if we consider lobbies in the EU that oppose the adoption of GMOs, it is probable that they prefer to intervene directly at the source, limiting the approval of GMO products and pushing for restrictive and complex approval and risk assessment procedures.

Considering labelling policies, the result of the *Export share* variable confirm the hypothesis that consumers in the EU and Japan are concerned about GMO products and a more restrictive labelling requirement would allow them a greater choice among products not containing GMOs. Moreover, countries with a higher share of rural population display a more restrictive labelling regulation. This result concerning agriculture structure is in line with the findings of Gruere *et al*. (2009), who showed that production interests play a prominent role in labelling decision-making.

With respect to coexistence measures, the comparative advantage proxy, *Land pc*, exerts a negative and significant effect on coexistence, suggesting that the greater the comparative advantage of a country in agriculture, the less the country will set restrictive coexistence requirements that can pose a burden on the agricultural activity. Moreover, countries with a wide share of organic lands will adopt comprehensive coexistence guidelines. Coexistence measures impose high management costs and reduce the per acre productivity due to uncultivated refugees and boundary areas. To ensure the profitability of their differentiated organic products, organic producers aim to avoid any mixing with non-organic products, particularly with GMOs, and this starts right from beginning production out in the field.

In our analysis, subscription to international agreements is motivated by several factors, and it is interesting that one of these is the tariff level seen in column (6).

Countries that have high tariff levels are more involved in international agreements that aim to set harmonized standards. These agreements are likely to have an increasing role in regulating food safety standards, and our results suggest that countries that have a high level of protection actively participate in the formation of international trade rules on GMOs. Moreover, countries that produce organic products, and that have an advanced environmental regulatory regime, are more involved in international agreements that aim to safeguard global biodiversity.

Finally, a prominent role in determining GMO regulatory components is played by media variables, especially on the most sensitive components to consumers , like risk assessment, labelling, traceability and coexistence. The media shows significantly less interest in the approval process and international agreements. This is an important confirmation of our interpretation of the mechanism through which the media affects GMO regulations; for example, in developed countries competition in the media market tends to encourage newspapers and TV programs to target (bad) news towards large consumer groups, which in turn can create a policy bias in that direction.

6. Summary and conclusions

The paper has built a composite index on GMO regulatory restrictiveness for 60 countries, including six regulatory categories, namely, approval process, risk assessment, labelling, traceability, coexistence and international agreements. This index provides an overview of the different GMO regulatory regimes world-wide. We confirm a significant polarization between GMO adopting and non-adopting countries, led by the United States on one side and the European Union on the other. Most of the developed and the importing countries of agri-food products tend to adopt restrictive GMO regulations, but in developing countries less restrictive requirements are more likely to be adopted, the exception being developing countries aiming at access to rich markets.

In a second step, our GMO regulatory index was used to study the determinants of regulatory restrictiveness. Starting from the main propositions highlighted in the theoretical literature, we tested the role played by explanatory variables clustered in four groups: trade and comparative advantage, agriculture structure, institutions and the media market. The results gave a general confirmation of several arguments suggested by the theory, showing that the main determinants of restrictive GMO regulation are the absence of comparative advantage in the agricultural sector, a strong presence in the country of rural population, and stringent environmental regulations. Moreover, tighter labelling requirements are driven by high exports to the EU and Japan, while a strong presence of organic farming leads to more restrictive coexistence measures. Last but not least, we empirically found a fundamental role played by the structure of the media market in determining the stringency of GMO standards. In rich countries, competition between commercial media induces information bias by disproportionally reporting 'bad news' on food safety issues – which translates into policy bias, namely more stringent GMO standards. In developing countries this relationship is reversed, as the main target group of the media-induced policy bias is the (large) farm group.

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Table 1. Country coverage and their GMO regulatory indexes

Rank	*Country*	*Index Value*	*Rank*	*Country*	*Index Value*
1	Hong Kong	0.10	9	Australia	0.55
2	Bangladesh	0.15	9	Switzerland	0.55
2	Peru	0.15	10	Norway	0.60
2	Sri Lanka	0.15	10	Poland	0.60
2	Turkey	0.15	10	Spain	0.60
2	Ukraine	0.15	10	United Kingdom	0.60
2	Venezuela	0.15	11	Germany	0.65
3	Israel	0.20	11	Greece	0.65
3	Jamaica	0.20	11	Ireland	0.65
3	Kenya	0.20	11	Luxembourg	0.65
4	Canada	0.30	11	New Zealand	0.65
4	Guatemala	0.30	11	Romania	0.65
4	Philippines	0.30	11	Slovakia	0.65
4	Singapore	0.30	11	Slovenia	0.65
4	South Africa	0.30	11	Sweden	0.65
4	Taiwan	0.30	12	European Union	0.69
4	Vietnam	0.30	13	Estonia	0.70
5	Chile	0.35	13	Finland	0.70
5	India	0.35	13	Japan	0.70
5	Indonesia	0.35	14	Austria	0.75
5	Malaysia	0.35	14	Belgium	0.75
5	Mexico	0.35	14	Czech Republic	0.75
5	United States	0.35	14	Denmark	0.75
6	Argentina	0.40	14	France	0.75
6	Thailand	0.40	14	Hungary	0.75
7	Colombia	0.45	14	Italy	0.75
7	South Korea	0.45	14	Netherlands	0.75
7	Russia	0.45	14	Portugal	0.75
7	Saudi Arabia	0.45	15	Zambia	1.00
8	Brazil	0.50	15	Zimbabwe	1.00
8	China	0.50			

Notes: the table reports the countries sorted in 15 ranks, from the less to the most restrictive GMO regulation. Within each rank, countries share similar level of restrictiveness and are sorted by alphabetical order. European Union has been calculated as the simple mean of the MS's indexes.

Table 2. Categories and conditions scores.

Regulatory Categories		*Score*
(1)	**Approval process**	
	Absence of GMO approval procedures	0
	Mandatory approval process, but far from enforcement	1
	Mandatory approval process adopting the principle of substantial equivalence	2
	Mandatory approval process adopting the precautionary principle	3
	Countries declared 'GM free'	4
(2)	**Risk assessment**	
	Absence of GMO risk analysis	0
	Proposed risk assessment, but far from enforcement	1
	Mandatory risk assessment	2
	Countries declared 'GM free'	3
(3)	**Labeling**	
	Absence of labeling policies	0
	Voluntary GMO labelling	1
	Mandatory GMO label without threshold or with threshold >1%	2
	Mandatory GMO label with threshold <= 1%	3
	Countries declared 'GM free'	4
(4)	**Traceability**	
	Absence of GMO traceability or an IP system	0
	GMO traceability far from enforcement, or is in place an IP system	1
	Mandatory GMO traceability	2
	Countries declared 'GM free'	3
(5)	**Coexistence**	
	Absence of coexistence rules	0
	GMO coexistence policies far from enforcement	1
	Partial guidelines on GMO and non-GMO coexistence	2
	Exhaustive guidelines on GMO and non-GMO coexistence	3
	Countries declared 'GM free'	4
(6)	**Membership in international agreements**	
	No adherence to international agreements	0
	Adherence to a single international agreement	1
	Adherence to both international agreements	2

Table 3. Summary statistics and correlations between regulatory categories.

	GMOindex	Approval Process	Risk Assessment	Labeling	Traceability	Coexistence	Agreements
Index Statistics							
Mean	0.49	0.57	0.61	0.53	0.33	0.24	0.87
Std. Dev.	0.23	0.29	0.18	0.31	0.34	0.32	0.26
Min	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Correlation Matrix							
GMOindex	1.00						
Approval Process	0.85	1.00					
Risk Assessment	0.66	0.66	1.00				
Labeling	0.88	0.75	0.60	1.00			
Traceability	0.89	0.66	0.47	0.75	1.00		
Coexistence	0.80	0.52	0.39	0.54	0.72	1.00	
Agreements	0.41	0.21	0.02	0.26	0.38	0.32	1.00

Table 4. Summary statistics of explanatory variables

	Year	Obs.	Min	Max	Mean	St. Dev.
EU-JPN Export share	1995	60	0.0004	0.783	0.142	0.169
Applied tariff	2005	60	0	82.100	14.654	13.070
Land pc	2005	60	0.0001	0.371	0.031	0.063
Organic	2000	60	0	0.130	0.024	0.032
Rural population	2005	59	0	84.900	32.839	20.590
Rural population sq	2005	59	0	7208.010	1495.175	1715.043
Polity2	2005	60	0	20.000	17.500	4.634
Erri	2001	60	0	3.835	1.702	0.965
Lobby	2002	56	1.1400	6.290	3.909	1.329
Share of private media	2003	60	0	1	0.697	0.226
Ln GDPpc*Share of private media	2003	60	0	10.538	6.242	2.226
Ln GDPpc	2003	60	5.9165	10.882	8.850	1.408

Notes: see text for variable explanation.

Table 5. Correlation matrix of explanatory variables

	EU-JPN Exp share	Applied tariff	Land pc	Organic	Rural population	Polity2	Erri	Lobby	Private media	Ln GDPpc
EU-JPN Exp share	1									
Applied tariff	-0.12	1								
Land pc	-0.18	-0.22	1							
Organic	0.49	-0.09	-0.02	1						
Rural population	-0.12	0.38	-0.22	-0.14	1					
Polity2	0.34	-0.26	0.12	0.27	-0.36	1				
Erri	0.42	-0.26	0.19	0.57	-0.51	0.32	1			
Lobby	-0.22	0.11	-0.02	-0.38	0.34	-0.07	-0.76	1		
Private media	0.04	-0.28	0.15	-0.05	-0.44	0.57	0.08	0.11	1	
Ln GDPpc	0.39	-0.29	0.15	0.44	-0.74	0.51	0.82	-0.60	0.32	1

Table 6. Determinants of GMO standard restrictiveness

Dependent: GMO Index	OLS		Spatial ML
	(1)	(2)	(3)
Trade and comparative advantage			
EU-JPN Export share	0.226**	0.011	0.182
	(0.105)	*(0.111)*	*(0.143)*
Applied tariff	0.000	0.001	0.000
	(0.001)	*(0.001)*	*(0.002)*
Land pc	-0.491	-0.593**	-0.449
	(0.463)	*(0.283)*	*(0.359)*
Agriculture structure			
Organic	0.479	0.833	0.274
	(1.011)	*(0.931)*	*(1.369)*
Rural population	0.011**	0.008**	0.012***
	(0.004)	*(0.003)*	*(0.004)*
Rural population sq	-0.0001***	-0.0001***	-0.0001***
	(0.000)	*(0.000)*	*(0.000)*
Institutions			
Polity2	0.002	-0.003	0.002
	(0.008)	*(0.006)*	*(0.007)*
Erri	0.131**	0.078*	0.135***
	(0.053)	*(0.041)*	*(0.050)*
Lobby	0.057**	0.039*	0.056**
	(0.025)	*(0.021)*	*(0.024)*
Media			
Share of private media	-2.971***	-3.080***	-2.921***
	(0.877)	*(0.570)*	*(0.657)*
Ln GDPpc*Share of private media	0.326***	0.357***	0.320***
	(0.111)	*(0.072)*	*(0.081)*
Ln GDPpc	-0.211***	-0.222***	-0.207***
	(0.077)	*(0.054)*	*0.065*
Constant	1.652**	1.921***	1.638***
	(0.702)	*(0.467)*	*(0.539)*
Regional fixed effects	NO	YES	NO
R-squared	0.624	0.843	
Observations	55	55	55
Moran's *I*	-0.012	-0.007	-0.019
p -value	*(0.291)*	*(0.177)*	*(0.474)*

Notes: robust standard errors in parentheses; regional fixed effects for Asia, Africa, Latin America, North America, Oceania, Middle East and the EU. In column 3, spatial regression with ML estimators. The Moran's *I* reports the test for spatial autocorrelation. A statistical not significant value of the index allows accepting the null hypothesis that there is zero spatial autocorrelation in the error residuals.

Table 7. Results of the spatial regressions with ML estimator on GMO regulatory components

	Dependent Variable					
	Approval	Risk Ass.	Labeling	Traceability	Coexistence	Agreements
	(1)	(2)	(3)	(4)	(5)	(6)
Trande and comparative advantage						
EU-JPN Export Share	0.261	0.165	0.393***	0.022	0.019	0.098
	(0.183)	*(0.119)*	*(0.177)*	*(0.197)*	*(0.202)*	*(0.167)*
Applied tariff	0.004**	0.002	-0.001	-0.004**	-0.003*	0.003*
	(0.002)	*(0.001)*	*(0.002)*	*(0.002)*	*(0.003)*	*(0.002)*
Land pc	0.209	-0.245	0.170	-0.858	-1.191**	-1.141***
	(0.490)	*(0.313)*	*(0.545)*	*(0.502)*	*(0.603)*	*(0.448)*
Agriculture structure						
Organic	-2.085	-1.178*	0.457	-1.852	4.034*	2.060
	(1.874)	*(1.182)*	*(2.060)*	*(1.907)*	*(2.278)*	*(1.682)*
Rural population	0.012**	0.010***	0.016***	0.011**	0.006	0.010**
	(0.005)	*(0.003)*	*(0.006)*	*(0.005)*	*(0.006)*	*(0.005)*
Rural population sq	-0.0002***	-0.0001***	-0.0002***	-0.0001**	-0.0001	-0.0001*
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Institutions						
Polity2	0.001	0.004	-0.003	0.008	0.009	-0.010
	(0.010)	*(0.006)*	*(0.011)*	*(0.010)*	*(0.012)*	*(0.009)*
Erri	0.218***	0.106***	0.080	0.140**	0.136	0.114*
	(0.070)	*(0.044)*	*(0.078)*	*(0.071)*	*(0.086)*	*(0.063)*
Lobby	0.088***	0.046**	0.050	0.044	0.047	0.056*
	(0.033)	*(0.021)*	*(0.038)*	*(0.034)*	*(0.042)*	*(0.031)*
Media						
Share of private media	-1.997**	-2.059***	-2.720***	-4.535***	-4.639***	-0.421
	(0.907)	*(0.578)*	*(1.012)*	*(0.928)*	*(1.116)*	*(0.812)*
Ln GDPpc*Share of private media	0.183*	0.215***	0.270**	0.521***	0.541***	0.083
	(0.111)	*(0.071)*	*(0.123)*	*(0.115)*	*(0.136)*	*(0.010)*
Ln GDPpc	-0.106	-0.129**	-0.152	-0.303***	-0.393***	-0.100
	(0.090)	*(0.060)*	*(0.100)*	*(0.093)*	*(0.110)*	*(0.080)*
Constant	0.681	1.245**	1.419*	2.215***	2.960***	1.052
	(0.743)	*(0.494)*	*(0.831)*	*(0.778)*	*(0.918)*	*(0.680)*
Observations	55	55	55	55	55	55
Moran's I	-0.015	-0.078	-0.008	-0.123	-0.010	-0.013
p -value	0.390	0.000	0.183	0.000	0.240	0.311

Notes: the results are from spatial regression estimated with ML estimator. Standard errors in parenthesis.