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ORIGINAL ARTICLE

Political and Economic Determinants of Asynchronous Approval of New GM Events

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Abstract

We use a political economy perspective to provide the first empirical analysis of the main political and economic determinants of asynchronous approval (AA) for a variety of countries over the period 2000–2015. The key results that emerge from our paper are the prominent role of regulatory quality and the number of internet users in a particular country in influencing AA across countries. We found that the higher the share of internet users in a country, the lower the AA. Consumer access to the internet makes them less exposed to negative news about genetically modified (GM) products, as they are less influenced by the negative bias of traditional mass media toward biotechnology. Additionally, the better the regulation quality (the more efficiently a government formulates and implements regulation), the shorter the time necessary to approve new GM events, and the lower the AA. Furthermore, our findings confirm that determinants such as corruption, trade relations with stringent markets, and the size of the rural population are also important in explaining AA of GM events.

Keywords: asynchronous approval; GM regulation; economic and political determinants; dynamic panel data

Asynchronous approval can potentially lead to disruption in the trade of agricultural commodities, as importing countries that have not approved GM events at the same time as exporting countries may decrease their imports or even halt imports due to the risk of contamination with GM events that are not approved for the domestic market. Trade disruption is likely to become more frequent and severe as more and more new GM products are developed and need to be approved by national regulatory authorities (Backus *et al.*, 2008; Kalaitzandonakes, 2011).

The literature has also shown that AA may have a substantial impact on the transaction costs of trade. For example, the GM maize variety, StarLink, had not yet been approved for human consumption in the United States when it was found in the human food supply (in taco shells), which caused a product recall, the redirection of shipments, and lawsuits against the developer (Carter and Smith, 2007). A second reported case by Ryan and Smyth (2012) refers to EU

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In countries that have already established GM regulation, a necessary condition for commercialization of a GM crop is the regulatory approval of each new GM event[1] for import or production (Kalaitzandonakes, 2011; Vigani and Olper, 2013). However, the regulatory approval processes for a new GM event differ considerably across countries. Thus, the same event is not approved simultaneously in different countries, which creates a situation known as asynchronous approval (AA) (Stein and Rodríguez-Cerezo, 2010).

[1]A GM event refers to a DNA recombination that is later used to create entire transgenic organisms. Plant lineage originating from transgenic events is considered genetically modified (GMO-COMPASS, 2013).

imports from Canada that were halted after the unapproved flax variety, Triffid, was detected in food products.

Many studies have applied the political economy perspective to explain both the formation and the heterogeneity of GM regulation across countries. Certain authors suggest that GM regulations may be determined by trade-related issues such as comparative advantage in GM technology (Anderson *et al.*, 2004; Veyssiere and Giannakas, 2006). Meanwhile, others have analysed the role of the media in shaping consumer perception of GM products (Curtis *et al.*, 2008; Olper and Swinnen, 2013). In addition to these studies, Gruère *et al.* (2009) considered domestic political factors, international trade, and macroeconomic issues as possible explanations for GM labeling policies.

Vigani and Olper (2013) concluded that the institutional environment, the strong presence of a rural population, and media market structure are essential determinants of restrictive GM regulation. Additionally, Vigani and Olper (2015) found that consumer behavior, producer interest, trade and comparative advantage, and the structure of the market for information are key factors in explaining GM regulation.

Extensive research has focused on explaining GM regulation, but little attention has been devoted to identifying the main factors driving AA. As highlighted by Faria and Wieck (2015), even countries that have very similar regulatory frameworks may differ considerably regarding AA, due to dissimilarities in their regulatory approval processes, particularly regarding the amount of time required to review and approve new GM events. Therefore, factors influencing GM regulation may not be the same as those determining AA.

This paper aims to fill this gap in the literature by providing a comprehensive examination of the main political and economic determinants of AA for cotton, maize, and soybeans, for a variety of countries over the period 2000–2015. It first addresses the critical issue of identifying the determinants of the AA of GM products. Second, the study considers how the actual AA index may be influenced by its values in previous periods, thus providing certain insights regarding the AA adjustment process over the years. Finally, the paper additionally allows for the endogeneity of independent variables.

Our results show that AA is a dynamic process that factors, such as a country's level of corruption, export access to stringent markets, and the size of the rural population, play a central role in explaining. However, the key result that emerges from our paper is empirical evidence regarding the existence of displacement effects of the internet on AA. We found that the higher the number of internet users, the lower the AA across countries, since these consumers are less influenced by the negative bias of the traditional mass media toward biotechnology. Additionally, we have found that regulatory quality (i.e. the efficiency in formulating and implementing regulation that benefits the private sector) plays a prominent role as a determinant of AA.

1. Background on GM Approval Process

Even if a GM event developer submits an approval request at the same time in different countries, it is very unlikely that a new GM event is approved simultaneously in all countries. This circumstance, defined as AA, is the outcome of dissimilar approval processes across countries (Stein and Rodríguez-Cerezo, 2010). Thus, AA depends on the politically optimal approval process of both importer and exporter.

Many situations may arise when comparing the GM approval processes between countries. The pace at which these processes take place depends mostly on political and economic factors. Political determinants can impact the environment in which GM approval processes occur within each country and thus contribute to AA. The quality of regulation can be a powerful political force in determining the magnitude of the AA, particularly in cases where countries have similar

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regulatory frameworks, and given that the quality of a regulation can reduce the overall time required for obtaining GM event approval.

The introduction of GM crops has driven countries to adopt domestic regulations concerning the production and consumption of food and feed products originating from these technologies to ensure their safe use for the environment and for human and animal health. The first regions to establish GM regulations – the United States and the European Union – followed different scientific approaches to GM products. While the EU invoked the precautionary principle and consumers' 'right to know', the US approach to regulating GM products was based on the principle of substantial equivalence, where regulation should focus on the nature of the products, rather than on the process by which they are produced (Gruère, 2006).

Gruère (2006) characterized eight groups of countries according to their regulatory framework, where one of the eight groups was GM product-free countries. Vigani and Olper (2013) characterized 15 clusters based on an index from Vigani *et al.* (2012), which takes into account six dimensions of the GM regulatory framework.[2] Faria and Wieck (2016) divided countries into three clusters based on national GM regulation components. That is, the initial differences in scientific approach between the EU and the US with respect to the GM regulation process have persisted over the years, and have become a benchmark for many countries (Vigani and Olper, 2015). These differences are themselves a potential source of AA. In addition, the approval process may be influenced by other issues within each country, and therefore heterogeneity across countries becomes the main potential source of asynchrony. Figure 1 presents some basic issues that may influence the GM approval process.

The production process is directly impacted by GM technology that increases productivity and/or decreases production costs. Thus, once a new technology shows potential to increase farmer profits, it is expected that farmers become willing to adopt it and support more lax regulations regarding that particular technology. However, this behavior may differ across countries, depending on their comparative advantage or disadvantage in producing that crop. Farmers in countries with a comparative advantage are expected to have an interest in adopting the GM technology once it is proven to increase production and export supply. Research on the determinants of GM regulation supports the view that trade and comparative advantage influence GM regulatory policies. Additionally, there is evidence that differences in comparative advantage in GM production may explain the lax regulation of GM products in the US and stringent GM regulation in the EU (Anderson *et al.*, 2004) .

A rational decision in an importing country with a comparative disadvantage in GM production would be for farmers to lobby against GM crops, or at least not support their adoption (Anderson *et al.*, 2004). According to Curtis *et al.* (2008), countries with fewer comparative advantages in agricultural production might use GM regulation as a protectionist measure, and thus adopt more stringent regulatory standards. In the EU moratorium scenario at the end of 1990s, Anderson *et al.* (2004) found that food-importing countries had an interest in foregoing GM product adoption in order to avoid increasing their comparative disadvantage to the exporting countries and to protect their own production.

In certain situations, the decision to adopt GM technology is based on the balance between potential gains and losses. Tothova and Oehmke (2004) and Vigani and Olper (2013) found that countries of similar bargaining power may synchronize their standards, if there are sufficient gains from trade. Regions with the most stringent requirements (the EU and Japan) encourage exporting partners to adopt similar regulation. Specifically, countries interested in exporting to the EU and Japan may have to comply with the restrictive GM regulations of these markets and synchronize their regulation with those of the EU and Japan if they want to maintain their market share in these regions (Gruère, 2006).

[2]Approval process, risk evaluation, labeling, traceability, co-existence, and international agreements participation.

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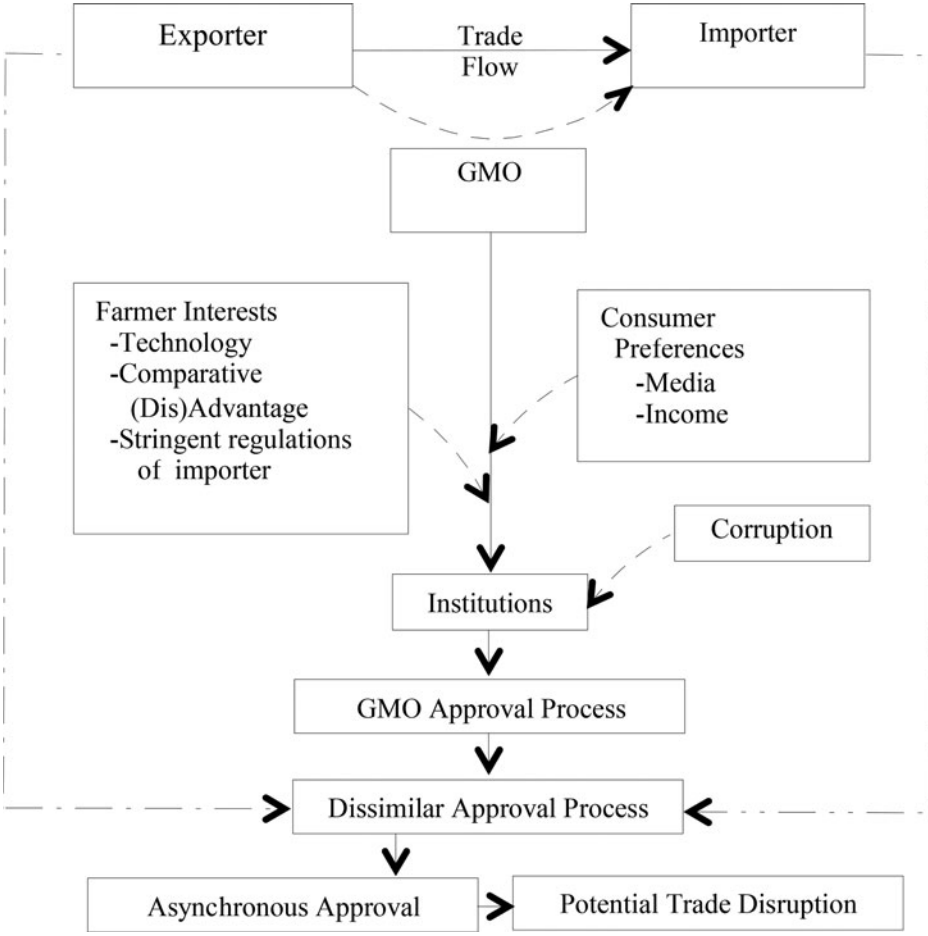

Figure 1. Major issues influencing regulation for the GM approval process
Source: Own compilation.

With regard to the demand side, consumer concerns exist around the potential health and environmental risks of GM foods. As food originated from genetically modified organisms have potential long-term risks that have not yet been fully demystified, consumers adopt various positions regarding demand for these products, and the income level of the population within a country can influence these stances. Depending on the consumer preferences and the income level, the price ratio may be sufficient to change the consumer's demand for a potentially risky product. While GM technologies directly impact crop production – decreasing costs and increasing productivity – they benefit consumers through lower food prices, since perceived product quality and characteristics usually seem the same. Thus, the total benefit of GM technology may not be sufficiently perceived by consumers, particularly if they have an established negative opinion regarding GM crops and if the price difference is not significant to the consumer (Vigani, 2017). Changes in consumer preferences concerning GM foods have an essential impact on reinforcing the lobbies for or against approval of GM events. Lusk *et al.* (2006) deny the conventional assumption that consumer preferences are homogeneous by highlighting differences in preference for GM food between the US and the EU.

The media can also influence consumer preferences. Several papers highlight the prominent role of the media in shaping consumer attitudes toward GM technology. According to

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McCluskey and Swinnen (2004), consumers generally prefer to consume negative news because this allows them to avoid negative outcomes and income losses. Media companies choose between their own preferences regarding the stories they publish and their profits, but are partially driven to promote stories that follow consumer preferences. Therefore, potential risks and consumer concerns about biotechnology are likely to be emphasized in the news.

According to Curtis *et al.* (2008), people in developing countries hold less negative attitudes against GM food than people in developed countries and at times even hold positive opinions about GM foods. This is partially explained by less exposure of consumers in developing countries to negative news due to the higher opportunity cost of keeping themselves well-informed, in addition to generally less media freedom in these countries.[3] In developing countries where increasing productivity and reducing food prices are important issues, and where governments may exert some influence over the media, consumers can be less exposed to negative news. In addition, media tends to focus on influential groups within the country. In agricultural-based economies, for example, agricultural innovation is more likely to be viewed more positively than in developed countries where consumers have more purchasing power and are more concerned with food safety issues (Vigani, 2017).

Internet access has played an important role in giving consumers access to sources of information other than traditional mass media, despite the fact that much internet news is not trustworthy (Vigani, 2017). Literature on the displacement effects of the internet abounds with examples where the internet displaces traditional mass media such as television, newspapers (Dimmick *et al.*, 2004), and radio (Lee and Leung, 2008). The time-displacement theory suggests that the use of one particular media may reduce the time spent with others, which is to say that the increase in internet usage may displace that of television, radio, and newspapers (Dutta-Bergman, 2004; Nie and Hillygus, 2002). However, internet users may seek out various sources on the internet and try to form their own opinion with respect to a certain topic, including GM products.

The arguments presented so far show substantial differences in opinion regarding GM products between the two main interest groups of farmers and consumers, and across countries. Farmers and consumers may either fight to achieve their own, opposing interests regarding GM product approval, or work together to influence government with respect to the approval process. The speed of the approval process therefore depends on the interactions among interest groups inside a country and on the overall country sentiment toward GM products. Swinnen and Vandemoortele (2011) drew a political economy model of food standards to analyse how the government simultaneously considers both the contribution of various lobbies, as well as domestic welfare, to determine a political equilibrium. In this model, consumers and producers are politically organized, and their lobbies contribute to influencing governmental decisions. According to the model, domestic welfare is defined as the sum of producer profits and consumer surplus. The government's objective function depends on the truthful contribution schemes of lobbies, weighted by the lobby's strength and by domestic welfare. Lobbies may either take a third-party view when farmers and consumers have differing opinions (such as the case of an exporting country that has a comparative advantage but consumers there present negative attitudes toward GM products), or lobbies may take a stance in agreement (when an importing country has lower comparative advantage and its consumers also have negative attitudes toward GM products, for example).

An important factor with regard to the GM regulation process is the quality of a country's regulatory authority. On the one hand, Kalaitzandonakes (2011) suggested that the capacity of regulatory agencies, the accuracy of the information submitted by the applicants for GM event

[3]According to Curtis *et al.* (2008), the fact that people in developing countries work on average three to four hours more than in developed countries would increase the opportunity cost for people in developing countries to obtain independent news. In addition, the government in many developing countries has an influence over the media.

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approval, and the speed at which this information is submitted can affect the speed of approving GM events and can ultimately cause AA. Governments can therefore decrease asynchrony by designing schemes to reduce the time lag between domestic and foreign approval. On the other hand, literature has shown that corruption is likely to decrease the effectiveness of regulation, to decrease the stringency of environmental policy, and can also be associated with environmental degradation in developing countries (Fredriksson and Svensson, 2003; Immordino and Pagano, 2003; Wilson and Damania, 2005). Concerning biotechnology, its opponents perceive that private interests corrupt public regulation (Newell and Glover, 2003); hence, the stringency of the approval process may be lower when corruption is high.

Taking into account the issues discussed above, many situations can arise that would lead to AA. Interactions among variables, and countries' particular interests can lead to different approval times for GM events. In Figure 1, the lateral dashed arrows illustrate this possibility. Finally, the stringency of the GM event approval process of the importing country is a critical issue in determining the potential impact of AA on international trade. On the one hand, a high level of AA may not be a risk to international trade if importing countries are less restrictive than exporting countries. On the other hand, even a low level of AA could lead to trade disruptions when the importer does not approve the GM events that are already approved by the exporters.

2. Empirical Framework

Figure 2 shows the empirical framework that is based on the literature review. We selected certain explanatory variables as proxies for the determinants of AA, grouped according to their political or economic characteristics. The political determinants are divided into 'institutions' and 'political power', while the economic determinants consist of 'trade and comparative advantage' and 'media and development'.

In our paper, AA is measured through the protectionism index (PI) developed by Li and Beghin (2014) and calculated by Faria and Wieck (2015).[4] The PI is defined on a bilateral basis (country pairs) by comparing the GM approval status for each and every GM event traded globally,[5] and is established by the importing and exporting country. The PI index takes into account both the dissimilarity and the stringency of the GM approval status between the importer and exporter. It ranges from 0 at the lower bound to $e \cong 2.72$ at the upper bound. A score of one indicates that importing and exporting countries have the same GM approval status, which means the absence of AA. A score higher than one indicates that the GM approval status of the importing country is on average more stringent than that of the exporting country. Under this circumstance, AA exists and may create trade disruption. Lastly, scores lower than one indicate that the approval status of the importing country is less restrictive than that of the exporting country, resulting in a situation where the existence of AA does not necessarily translate into trade restrictions. The measurement of AA for each importer is obtained by calculating the average of the

[4]Let $R_{ikm_{(kt)}}$ be the approval status for a GM event in exporting country i; let $R_{jkm_{(kt)}}$ be the approval status for a GM event in exporting country i; let be the approval status for the same event, product, and year for importing country j. $M_{(kt)}$ denotes the total number of GM events for each product k in given year t. The approval status is ranked as: 1 if the GM event is not approved for any use; 2 if the GM event is approved only for feed; 3 if the GM event is approved only for food; and 4 if the GM event is approved for food and feed. The importer–exporter index is calculated as follows:

$$PI_{jikt} = \frac{1}{M_{(kt)}} \left(\sum_{m_{(kt)}=1}^{M_{(kt)}} \exp \frac{(R_{ikm_{(kt)}} - R_{jkm_{(kt)}})}{\max(R_{m_{(kt)}}) - \min(R_{m_{(kt)}})} \right)$$

[5]Based on the market status for each event in 2015 (event is globally commercialized or not) and considering the first year of approval worldwide, we categorize an event as either commercialized or not for the period 2000–2015. The PI index relies on 27 commercialized events for cotton, 55 for maize, and eight for soybeans.

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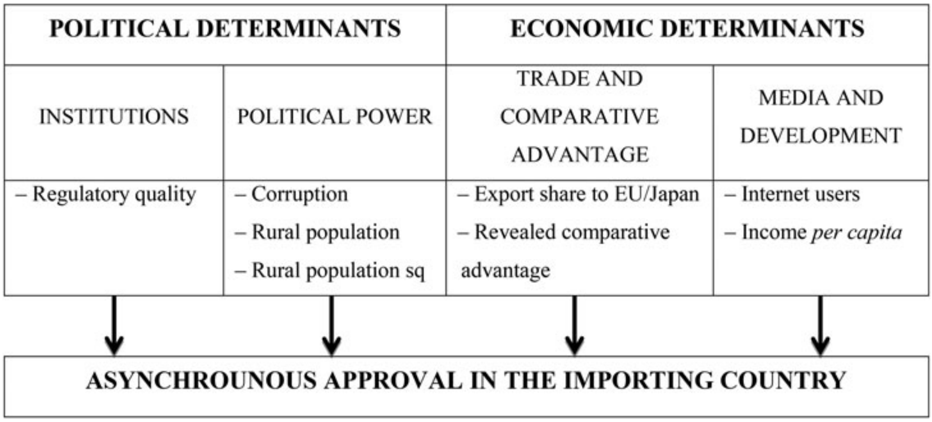

Figure 2. Explanatory variables for the political and economic determinants of AA
Source: Own elaboration.

country pair scores for each importing country, considering all exporters in the sample. Appendix Table 1 shows the average PI index for the importers in our sample.

As highlighted by Faria and Wieck (2015, 2016), calculating the PI indices involves taking certain critical issues into account. First, the regulatory approvals considered in this paper are those for importation, specifically. Second, we consider non-established GM regulation as the most restrictive approval status, since in our sample the majority of countries that lack GM regulation do not approve GM events. This issue translates into higher PI values for countries such as Bangladesh and Thailand, although many such countries import GM products, implying that the non-approval of a GM event is not the same as prohibiting its import. Instead of treating non-established regulation as the most restrictive approval status, another possibility would be to treat non-established regulation as the least restrictive approval status. This would then take into account situations where a lack of regulation is *de facto* a synonym for complete liberalization. The decision on how to treat non-established regulation is usually driven by the characteristics of the sample (Winchester *et al.*, 2012; Li and Beghin, 2014). Finally, only commercialized GM events are considered for the index calculation. As a result, the PI values for this calculation are considerably lower than the values found when considering all GM events.

The Worldwide Governance Indicators (WGI) of the World Bank define regulatory quality (RQ) as the ability of the government to formulate and implement policies and regulation that promote private sector development. We assume that the quality of regulations influences the efficiency of the approval process for GM events (i.e., the higher the quality of regulations, the shorter the time necessary to approve new GM events, and the lower the AA). In addition, based on Vigani (2017), one may argue that if the level of the public trust in the ability and competence of the government to formulate and implement policies is high, the public becomes less demanding regarding the approval process.

The WGI also define corruption as the perception of the extent to which public power is exercised for private gain. It ranges from –2.5 (the lowest corruption level) to 2.5 (the highest corruption level). Theoretically, corruption could either decrease the stringency of the approval process, reducing AA, or reduce the efficiency of the approval process, increasing AA.

Data on rural population (Vigani and Olper, 2013) and employment in agriculture as a share of total employment (Fredriksson and Svensson, 2003) have been used as proxies for the strength of the agricultural lobby. A non-linear relationship may exist between group size and the importance of votes, and the introduction of the rural population – both linear and squared – may capture the trade-off off between smaller group lobbying activities and the voting weight of the rural

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population (Vigani and Olper, 2013). Therefore, the expected effect of the lobby variable on AA is ambiguous.

The export share to the EU and Japan represents trade dependence, when a country has the EU and Japan as its major importers of GM products; i.e., the higher the export share to both markets, the higher the level of AA, as Japan and countries in the EU may establish more stringent approval processes. We assume that if a country has a comparative advantage in the production of cotton, maize, and soybeans, it also has comparative advantage in GM production, since a significant share of cotton, maize, and soybean production is GM. We hypothesize that countries with comparative advantage may exhibit a less stringent GM approval process, and hence may approve GM events faster, lowering the AA. The analysis applied the revealed comparative advantage index (Balassa, 1965) to proxy for comparative advantage in GM production. The Normalized Revealed Comparative Advantage (NRCA) ranges from –1 to 1. The lower bound represents a situation where the importing country does not have a comparative advantage in GM trade, while the upper bound represents a situation where the importing country has a comparative advantage in GM trade.

Although negative news regarding GM products is relatively common on the internet, the user plays an active role in searching among online news and has the opportunity to research information on the benefits of GM foods, whereas television viewers absorb the information that is chosen by the particular news program. As argued by Vigani (2017), internet users are not only consumers of news, but they also have the opportunity to make comments and engage with a given social network. According to the time displacement theory, we expect that the higher the number of internet users, the less the exposure to negative news about biotechnology from the traditional mass media – particularly in developed countries. In developing countries, this behavior could be reversed since the media there can be biased toward the benefits of biotechnology. For example, in developing countries with a large agricultural sector, the media tends to focus on the livelihood of farmers. If the government there is pro-GM products, less exposure to traditional mass media in such countries would make consumers less willing to support GM products.

Additionally, consumers in more developed economies may display significant risk aversion to GM products and have higher demand for quality. Therefore, the level of economic development may positively affect the stringency of GM regulation, and slow the approval of GM events. We use per capita income (in current USD) as a proxy for the level of economic development.

The econometric equation to test the political and economic determinants of AA follows

$$\begin{aligned} PI_{k,j,t} = {} & \alpha_j + \beta_1 PI_{k,j,t-1} + \beta_2 RQ_{j,t} + \beta_3 Corrup_{j,t} + \beta_4 RuralPop_{j,t} + \beta_5 RuralPopsq_{j,t} \\ & + \beta_6 ExpShareEU\_JPN_{k,j,t-1} + \beta_7 NRCA_{k,j,t} + \beta_8 IntUsers_{j,t} \\ & + \beta_9 GDPpc_{j,t} + u_{k,j,t} \end{aligned} \tag{1}$$

where k denotes the type of commodity (cotton, maize, and soybeans), j denotes the importing country, t denotes the year, α_j are the unobserved country effects, and β_1 through β_9 are the coefficients to estimate. Following Faria and Wieck (2015), we consider 40 countries that have a significant share in the international trade of GM cotton, maize, and soybeans.[6] We assume a

[6]The countries are: Argentina, Australia, Bangladesh, Bolivia, Burkina Faso, Brazil, Canada, Costa Rica, Chile, China, Colombia, Egypt, El Salvador, European Union, Honduras, India, Indonesia, Iran, Japan, Malaysia, Mexico, Myanmar, South Korea, Pakistan, Paraguay, Peru, the Philippines, New Zealand, Russia, Saudi Arabia, South Africa, Switzerland, Taiwan, Thailand, The United States, Turkey, Ukraine, Uruguay, Uzbekistan, and Vietnam. The Harmonized System Codes (HS codes) for cotton are: 120720, 151221, 151229, 230610; (HS codes) for maize are: 100510, 100590, 230310; and (HS codes) for soybeans are: 120100, 150710, 150790, 230400.

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three-year interval as adequate for evaluating changes in the stock of GM events over time. Thus, we take data for every three years for the period 2000–2015.

Since PI values are higher for countries that lack GM regulation, we verify the robustness of our results by estimating the baseline sample, which includes all the importing countries, and a GM adopter sample that comprises the importing countries that allow imports only of GM products whose events are pre-approved by their competent authorities.

We obtained data on regulatory quality and corruption from the WGI. We used data on rural population as a share of total population, the number of internet users as a share of total population, and per capita income from the World Development Indicators (WDI) of the World Bank. We calculated the PI index as proposed by Faria and Wieck (2015). Finally, we calculated the share to the EU and Japan of total exports of commodity k and calculated the normalized revealed comparative advantage (Balassa, 1965) using data from the United Nations Commodity Trade Statistics (UN-COMTRADE).

Serial correlation may be present in our sample, as the AA of year t depends on its previous observation in $t-1$. In addition, as noted by Faria and Wieck (2015), where the AA of GM events was found to have an impact on international trade, some endogeneity bias may be present in trade-related variables such as export share to the EU and Japan.

We use the generalized method of moments (GMM) estimator of Arellano and Bover (1995) and Blundell and Bond (1998). The system GMM estimator is based on the instrumental variables method. Specifically, it associates a basic set of equations in first differences with appropriately lagged levels as instruments, with another set of equations in levels with appropriately lagged first differences as instruments, and thus depends on the validity of the moment conditions. The validity of these additional instruments can be tested using the Sargan test of over-identifying restrictions or by using Difference Sargan or Hausman comparisons between the first-differenced and the system GMM results (Bond *et al.*, 2001). Under the null hypothesis of the above tests, the instruments are valid.

The consistency of the system GMM estimator depends on not having a second-order serial correlation in the residuals of first-differenced equations. It can be checked by the Arellano-Bond test for AR(1) and AR(2) in first differences.

To assess potential simultaneous causality bias between trade-related variables and the AA, the export share to the EU and Japan is assumed to be endogenous, which means that the export share may be a determinant of AA and in turn, AA may affect the export share.

3. Results

Table 1 shows the average, minimum and maximum values of both dependent and explanatory variables for the baseline sample and the adopter sample. The average regulatory quality is far superior in countries with GM regulations, while the opposite occurs with average corruption levels. Average per capita income of countries with GM regulation is almost twice as high of that in countries without, and the share of internet users in countries with GM regulation is, on average, one and a half times greater compared to the baseline sample. The average export share to the EU and Japan is also higher for GM-regulated countries, while the average share of the rural population is higher in the baseline sample, reaching 37% of the population.

Results of the dynamic panel data model on the primary determinants of AA are shown in Table 2. Autocorrelation tests were valid for both samples.

The lagged dependent variable is positive and statistically significant at the 1% significance level for every sample, confirming the dynamic nature of AA. The adjustment coefficient, which is given by 1 β_1, is relatively small (less than 0.5 in both cases), offering evidence that countries adjust their GM event approval status somewhat slowly, especially recalling that the observation is lagged by three years. One plausible explanation lies in the fact that the approval

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Table 1. Average, minimum and maximum values of the variables

Variable	Theoretical range	Baseline sample			GM adopter sample		
		Min	Avg	Max	Min	Avg	Max
Protectionism Index (*PI*)	[0;*e*]	0.43	1.14	1.59	0.43	1.00	1.59
Regulatory Quality (*RQ*)	[−2.5;2.5]	−2.25	0.14	1.95	−0.56	0.74	1.95
Corruption	[−2.5;2.5]	−2.46	−0.04	1.73	−2.46	−0.63	1.09
Rural population	[0;1]	0.05	0.37	0.82	0.07	0.28	0.72
Rural population squared	[0;1]	0.01	0.18	0.68	0.01	0.10	0.52
Export share to EU/ Japan	[0;1]	0.00	0.20	1.00	0.00	0.25	1.00
Normalized revealed Comp. Advant. *(NRCA)*	[−1;1]	−1.00	−0.60	1.00	−1.00	−0.62	0.92
Internet users	[0;1]	0.00	0.31	0.93	0.01	0.46	0.93
GDP pc (thousands)	[0;∞]	0.23	11.27	83.28	0.45	20.02	83.28

Source: Own elaboration.

processes for GM events are known to be quite time-consuming, and therefore the processes may not dramatically change from one period to another. Additionally, the lagged value of PI is greater for the baseline sample – as it includes countries that lack GM regulation – and lower for countries that possess a GM regulatory framework. This result is expected, as a lack of GM regulation is assumed to be the most restrictive status in the index calculation, and therefore the asynchrony of previous periods in the baseline sample may be higher and also exert pronounced effects on the current period.

The negative and statistically significant coefficient for the regulatory quality variable supports the hypothesis that when the quality of formulation and enforcement of standards is high, the AA decreases. Countries with reliable and transparent regulatory schemes are likely to find it easier to approve GM events, which in turn reduces AA. In addition, according to Takeshima and Gruère (2011), improving the efficiency of GM regulation is an alternative to removing institutional constraints such as limited resources dedicated to research and development, weak regulatory capacity, and a lack of law enforcement capacity. The effects of regulatory quality on AA are stronger for the subgroup of GM-regulated countries, implying that high-quality regulation may translate into a less bureaucratic and time-consuming approval process.

The impact of corruption on AA is negative in both samples, which may appear as contradictory. One would expect that the higher the corruption level, the higher the AA, as corruption can decrease the effectiveness of regulation enforcement and reduce transparency. However, a higher level of corruption may be associated with a less stringent approval process. In corrupt regimes, circumventing regulation may be achieved by bribing corrupt agents. In such a circumstance, AA would be reduced as a consequence of less stringent regulation.

The coefficients for rural population, both linear and squared, are statistically significant for countries that possess a GM regulatory framework. The opposite signs indicate that the share of rural population increases the PI at decreasing rates. On the one hand, the positive relationship between rural population and PI indicates that larger rural populations have difficulty overcoming problems of free riding, therefore resulting in more stringent GM regulation. This result may illustrate that in some countries, small groups face fewer problems of free riding and therefore lobby in favor of more stringent approval processes, as is the case in the EU. According to

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Table 2. Results of the political and economic determinants of AA

Dependent: Protectionism index	Baseline sample	GM adopter sample
Protectionism index lag 1	0.79*** (0.05)	0.64*** (0.08)
Regulatory quality	−0.03** (0.02)	−0.14* (0.07)
Corruption	−0.07*** (0.02)	−0.19*** (0.04)
Rural population	0.16 (0.18)	1.51*** (0.54)
Rural population sq	−0.22 (0.20)	−1.95*** (0.60)
Export share to EU/Japan lag 1	0.06** (0.03)	0.08 (0.05)
NRCA	−0.01 (0.01)	0.02 (0.02)
Internet users	−0.24*** (0.06)	−0.09 (0.13)
ln(GDPpc)	−0.01* (0.01)	−0.08 (0.05)
F-test	4252.91***	888.15***
Estimator	System GMM	System GMM
Instruments/groups	23/117	23/54
Sargan Test	9.25	12.49
AR(1) in 1st difference	−3.80***	−2.80***
AR(2) in 1st difference	0.22	−0.94
Time effects	Yes	Yes
Obs	576	267

Notes: Heteroscedastic robust standard errors in parentheses. Asterisks***, **, and * indicate significance level at the 1%, 5%, and 10%, respectively.
Source: Own calculation.

Anderson and Jackson (2003) and Graff and Zilberman (2004), EU producers benefit from stringent GM regulation, as the additional cost to small EU farmers of adopting GM technology often outweighs their potential gains. Moreover, the choice of EU producers to not adopt GM events also provides them with the opportunity to have a differentiated, conventional crop, and maintain technical barriers to trade. On the other hand, the negative sign of the squared rural population coefficient shows that the problems with free-riding are gradually off-set, as a significant share of the rural population becomes more powerful in influencing political decisions through their voting weight. According to Vigani and Olper (2013), these results indicate the trade-off between the voting weight of a specific group and its strength on lobbying activities.

According to Gruère *et al.* (2009), trade relationships may encourage imitation of GM regulations. For example, food and feed exporters to the EU and Japan are more likely to have adopted more stringent GM regulations. The lagged coefficient of the export share to the EU and Japan is positive and statistically significant at the 5% significance level for the baseline sample. This result is in line with the theoretical hypothesis, as the European and the Japanese markets are known to have stringent GM regulations. To trade with the EU and Japan, countries are encouraged to imitate their rules – particularly if the country is small in comparison to the EU and Japan. The

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coefficient is not significant for the GM adopter sample which is consistent with the fact that major exporters such as Brazil, Argentina, and the United States adopt less stringent GM regulation since they cultivate GM crops both for domestic consumption and export.

The percentage of internet users in a given country has a negative effect on AA at the 1% significance level in the baseline sample. These results may indicate that the easy internet access of consumers displaces the consumption of more traditional mass media, and therefore makes internet users less influenced by the negative bias toward biotechnology of the traditional mass media. When consumers are less exposed to negative news regarding GM products, their positive perception of biotechnology improves, which reduces their lobbying against the approval of new GM events.

The coefficient of per capita income is negative and statistically significant at the 1% significance level in the baseline sample. Although a positive coefficient was expected, since the demand for safety regulation is elastic to income level, our finding is in line with the characteristics of our sample. As the majority of countries that have not adopted GM regulation is poor, and as they present higher PI values, an inverse relationship between per capita income and AA emerges. Similar result was found by Vigani and Olper (2013) in which per capita income influences the GMO standard restrictiveness negatively.

4. Conclusion

This paper addresses the important issue – not examined in prior studies – of identifying the main determinants of the AA of GM events across countries.

We found evidence that some of the most common political and economic factors demonstrated by the literature as the determinants of establishing GM regulation are also determinants of AA. However, our results provide compelling evidence regarding the existence of other critical factors primarily driving AA, such as regulation quality and internet use.

Regulatory quality appears to be essential in improving the efficiency of the approval process, as countries with high-quality GM regulation present lower AA. Our findings revealed that the impact of political and economic determinants on AA are more pronounced in countries with GM regulations, demonstrating once again the importance of the regulatory system in the approval process for GM events.

While internet users may be subject to negative news about GM products – particularly in regions such as the EU, where anti-GM groups are increasingly active online, our findings suggest that the internet in many countries may be displacing more traditional mass media. Our results showed that a higher share of internet users in a country leads to less AA, although in certain countries this may not be the case due to other critical issues such as consumer preferences.

Finally, our findings are consistent with the claim in the literature that AA has a dynamic nature (i.e., that current asynchronicity is influenced by previous AA values). On average, countries that present low or high AA in one period are likely to repeat the pattern in the next period, since the adjustment process of AA is relatively slow and taking action to decrease asynchrony (e.g. to improve GM regulation) can be considerably costly.

Our results suggest the importance of strengthening regulatory institutions through transparency and reliable information, as well as establishing effective communication with internet users since they are increasingly subjected to news and information regarding both the risks and the benefits of GM products.

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Appendix

Appendix Table 1. Average PI index for importers

Country	2000	2003	2006	2009	2012	2015
Argentina	0.87	0.95	1.02	1.10	0.97	1.00
Australia	0.91	0.92	0.87	0.91	1.03	1.06
Bangladesh	1.16	1.29	1.33	1.36	1.41	1.40
Bolivia	1.16	1.29	1.15	1.24	1.31	1.35
Brazil	1.02	1.13	1.13	1.04	0.89	0.90
Burkina Faso	1.16	1.29	1.33	1.32	1.37	1.39
Canada	0.60	0.68	0.73	0.77	0.90	0.92
Chile	1.16	1.29	1.33	1.36	1.41	1.40
China	1.11	0.94	0.96	1.06	0.95	0.92
Colombia	1.16	1.18	1.24	1.17	0.92	0.92
Costa Rica	1.16	1.29	1.33	1.36	1.41	1.40
Egypt	1.16	1.29	1.33	1.36	1.41	1.40
El Salvador	1.16	1.29	1.33	1.36	1.41	1.40
EU	0.96	0.98	1.08	1.01	0.85	0.78
Honduras	1.16	1.29	1.33	1.36	1.41	1.39
India	1.16	1.29	1.33	1.36	1.40	1.22
Indonesia	1.16	1.29	1.33	1.36	1.24	1.29
Iran	1.16	1.29	1.33	1.36	1.41	1.40
Japan	1.03	0.54	0.52	0.53	0.60	0.56
Malaysia	1.16	1.29	1.33	1.36	1.10	1.16
Mexico	0.95	0.86	0.74	0.74	0.74	0.75
Myanmar	1.16	1.29	1.33	1.36	1.41	1.40
New Zealand	0.85	0.86	0.82	0.86	0.99	1.02
Pakistan	1.16	1.29	1.33	1.36	1.41	1.40
Paraguay	1.16	1.29	1.15	1.22	1.26	1.33
Peru	1.16	1.29	1.33	1.36	1.41	1.40
Philippines	1.16	0.85	0.79	0.67	0.78	0.77
Russia	1.16	1.29	1.28	0.96	1.07	1.15
Saudi Arabia	1.16	1.29	1.33	1.36	1.41	1.40
South Africa	1.16	1.03	1.09	1.19	1.10	0.94
South Korea	1.16	0.87	0.69	0.60	0.60	0.63
Switzerland	0.93	1.06	1.11	1.22	1.29	1.33
Taiwan	1.16	1.05	1.08	0.92	0.93	0.81
Thailand	1.16	1.29	1.33	1.36	1.41	1.27
Turkey	1.16	1.29	1.33	1.36	1.23	1.23

(Continued)

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Appendix Table 1. (*Continued.*)

Country	2000	2003	2006	2009	2012	2015
Ukraine	1.16	1.29	1.33	1.36	1.41	1.40
United States	0.58	0.62	0.63	0.63	0.75	0.93
Uruguay	1.02	1.10	1.12	1.22	1.08	1.25
Uzbekistan	1.16	1.29	1.33	1.36	1.41	1.40
Vietnam	1.16	1.29	1.33	1.36	1.41	1.15

Source: Own calculations.

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