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The Political Economy of Food Standards: GMOs Regulation and Trade

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Introduction

After a wide proliferation in the last decades, nowadays standards are globally diffused and are having effects on world market. Adoption of public standards grew both in numbers and variety, including several areas like nutrition (e.g. low fat), health (e.g. low pesticide residue), quality (e.g. organic), safety (e.g. equipment safety measures), environment (e.g. low carbon dioxide emission) and social concerns (e.g. no child labor).

Standards introduction is a controversy issue, their adoption has been justified as a response to consumers concerns but they are also affecting trade. Several authors pointed out that public standards represents a new form of non tariff barriers (NTBs) and protection-in-disguise (Sturm, 2006). Moreover, standards are increasing proportionally with the progressive limitation imposed by international trade agreements on traditional forms of protectionism (tariffs and export subsidies). In this view, standards are an instrument of protectionism against imports (Anderson *et al.*, 2004; Fischer and Serra, 2000).

Nevertheless, this interpretation is in contrast with some empirical observations. As a matter of fact some quality public standards are introduced following consumers' demand and in many cases producers have opposed their introduction. This evidence created a new point of view, because, if public standards are protectionist instruments, producers should support while consumers should oppose them. Tian (2003) and Marette and Beghin (2010) showed that a standard may be anti-protectionist when foreign producers are more efficient in comply with standards' enforcement than domestic producers.

At the same time, private companies have increased the introduction of private standards, parallel to public standards (Henson, 2004; Fulponi, 2007). Retailers and producers have the possibility of introducing private standards in the same domains as in which the government imposes public standards, such as safety, quality, and social and environmental aspects of production and retailing.

There are a variety of motives for companies to implement private standards. First, they may reduce consumers' uncertainty about product characteristics increasing consumer demand and facilitate firms to gear their activities to one another along the production chain (Arora and Gangopadhyay, 1995; Kirchhoff, 2000). Second, firms may also use private standards as a strategic tool to create market segmentation by differentiating their products and softening competition (Mussa and Rosen 1978; Tirole 1988). Finally, private standards may also serve to preempt government regulations, because firms may have an incentive to commit to a quality level before public standards are set, in order to induce the regulator to weaken public standards. Private standards are also more flexible in response to changes in consumer preferences and in technology (Lutz et al., 2000; McCluskey and Winfree 2009).

In this context, we analyzed the role of public and private food standards on the global food market, focusing on genetically modified organisms (GMO) standards. The focus on GMOs is motivated by the relevance and sensitivity of this issue, both politically and commercially, in developed and in developing (emerging) countries.

In the first chapter we present the problem of food standards, providing classification and definitions. We distinguished between public and private standards, discussing economic aspects on trade and welfare and problem related to their measurement for an assessment of their economic impact.

In the second chapter we develop a composite index of the 'complexity' of GMOs regulations for sixty countries, assigning 'objective' scores to six GMO regulatory sub-dimensions. We include most of EU countries and OECD members, important exporters of agricultural goods and developing (emerging) countries. The criteria for choosing the countries was based on both their economic relevance in the agricultural international markets, as well as sufficient availability information related to laws and acts regulating GMO cultivation and commercialization. The main information source used is the 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 refer to official national acts, reports or essays. We considered the period until June 2008.
Six categories of GMO production and commercialization regulations were considered:

1. Approval process;
2. Risk assessment;
3. Labeling policies;
4. Traceability system;
5. Coexistence management;
6. Membership in international agreements GMO related.

Each GMO regulatory dimension was scored. Higher scores indicate an increasing restrictiveness of the regulation. The overall GMO index is then obtained by summation and normalization so that it can take on any value between 0 and 1. Higher values indicate a more complex regulation on GMO production and commercialization, which suggests increasing restrictions to cultivation and trade.
Following Anderson (2009) and Jaffe (1986) we calculate a cosine similarity index and we developed an empirical framework to study the determinants of GMO similarity index. Specifically, we run OLS regressions comparing two different measures of GMO

bilateral index. Independent variables are related to three main categories: trade costs, institutional difference and economic controls.

In Chapter 3, the GMO index has been used as key input to investigate the trade effect of GMO standards across a large sample of developing and developed countries. The aim is to capture the potential trade effect of 'harmonization' in GMO regulations. Thus we tried to understand how much does similarity (dissimilarity) in GMO regulations between exporting and importing countries affect bilateral trade in GMO sensitive commodities. Moreover, having showed in the first essay that trade related variables are robust predictors of the similarity in GMO regulation, we also take into account the potential bias induced by the endogeneity of GMO standards to trade flows in the gravity equation, a problem rarely investigated in the actual literature. We used a theory-driven gravity model to estimate the GMO trade effect, considering four main products: maize, soybean, rapeseed and cotton; as a total aggregate and individually. In the model we included: exporter and importer fixed effects, the transport costs proxied by distance between countries, bilateral tariff, and the standards gravity covariates (common language, contiguity and past colony relationships). We augment this trade equation introducing bilateral GMO index. As in the first essay, following Anderson (2009) and Jaffe (1986) we calculate a cosine similarity index, and we test the robustness of our findings by using a GMO dissimilarity index measured as the absolute deviation between the value of the indexes of two countries which permitted us to estimate also the effect of each components of the regulation. Our econometric strategy was to control for selection bias correction due to zero trade flows using the methodology proposed by Heckman (1979) and the modification suggested by Helpman *et al.* (2008) and supported by Martin and Pham (2008). Furthermore, to deal with the potential endogeneity of GMOs regulation to trade flows, we instrument the GMO index by using the weighted average GMO index of the five closest neighbors following Djankov *et al.* (2010).

In the fourth chapter our question is to better understand why a retailer is willing to set its private standards at a higher level than the public ones. To comply with this purpose, we structured our essay in two main parts. The first section develop a political economy model following the approach of Swinnen and Vandemoortele (2009) which is based on the seminal model of Grossman and Helpman (1994). We specify the different agents in our model: consumers, producers and the retailer; we show how a standard affects them and we derive the market equilibrium. We analyze the level of government' public standard when is determined in a political economy game where producers and the retailer contribute to the government to influence the public standard-setting process. We determine the retailer's optimal private standard and we compare it with the politically optimal public standard and show under which conditions the public standard is set at lower levels than the private one. We limit ourselves to a closed-economy model to refrain from barriers-to-trade issues. Results showed that if producers have sufficiently more political power than the retailer, the latter may use its market power to unilaterally set a private standard at a higher level than the public standard. Hence our model combines both aspects of retailers' market power and producers' political power to explain why private retailers' standards may be set at higher levels than public standards. In the second section we observe if the model fits with the reality providing empirical evidences. We collected information from 45 retailers groups, consisting of 183 different supermarkets brands, obtaining statements on GM-free standards from retailers' web pages, and annual financial and sustainability reports. For missing information we contacted the retailers' customer services directly. We divided retailers into three categories: retailers with a GM-free standard, retailers that potentially adopt GM ingredients, and retailers that have no objection to the use of GM. Our finding are consistent with the model's prediction.

Finally, we provide overall conclusion from the results of each analyses.

Chapter 1

Agri-food Standards and Trade: A Review

1.1 Introduction

In the last decades international agreements on trade promoted by the World Trade Organization (WTO) and other regional sub-agreements of some self selected group of countries, like the South Common Market (Mercosur) or the North American Free Trade Agreement (NAFTA), reduced tariff barriers to promote worldwide free trade. In parallel with the reduction of tariff barriers, other forms of non-tariff measures (NTMs), or non-tariff barriers (NTBs), such as quotas, technical regulations or more generally standards, increased. NTMs progressive diffusion showed an impact on trade, often restricting imports, and their role has been considered of protection in disguise, as a substitute for, or a complement to tariff barriers. But their protectionist effect is still uncertain, while their market segmentation effect is widely recognized due to great differences in NTMs design and levels among countries.

According to WTO rules, standards can fall into two main categories: the first category refers to general technical regulations dealt under Technical Barriers to Trade Agreements (TBT); the second one concerns standards imposed to protect human, animal or plant health under the Sanitary and Phytosanitary Agreements (SPS). A country can either impose a mandatory standard, with which producers are obliged to comply, or a voluntary one.

In general, agri-food product standards specify a level of quality or attainment, defined by product or production process characteristics. Standards are a typical feature of product differentiation, in particular of vertical differentiation, in which products can be rated with respect to their process-attributes (e.g. organic or excluding child labor) or their content-attributes (e.g. content of pesticide residuals or micotoxins).

Agri-food products can be also horizontally differentiated, but horizontal product characteristics are not objectively measurable (e.g. colour or taste). For example, country of origin labeling requirements are diffused in the agri-food sector and represent a feature of horizontal differentiation, because it is not possible to establish any objective qualitative characteristic based only on the product provenience. The product differentiation in different countries due to different standard' requirements leads to the market fragmentation effect, including several economic and trade effects (see section 1.2).

A further important distinction on product and process standards is based on the level of adoption. Agri-food standards are set both by governments through national or regional regulations and the private sector, at company or retailer level, by internal policies. While public standards are set on the basis of welfare considerations or on consumer health and safety concerns, private standards are driven by strategic considerations at the firm level, such as gaining greater market shares by products differentiation.

Despite the fact that public and private standards often concern similar attributes, their effect on the global market and on the relationships between economic agents (i.e. producers, transformers, retailers and consumers) could be significantly different. For this reason, in this chapter we treat these two types of standards separately. First we will present public standards, their classification and their recognized economic effect on trade and welfare, as well as problems related to their definition and measurement. Second we will discuss the specificities of private standards. Finally we will present our strategy in dealing with this broad issue and explain our contribution in the study of the political economy of standards.

1.2 Classification and trade effects of public standards

Agri-food standards are designed differently depending on what they want to regulate, for example improving human health or social externalities. A first distinction is between product and process standards. (See table 1 for an exhaustive classification of standards in the agri-food sector.)

Product standards typically consist in setting maximum levels of permitted residuals of pesticides, herbicides, additives, drugs, or other contaminants (e.g. micotoxins) or minimum levels of nutrients, such as fats or proteins. In certain cases a product standard can consist in the ban of certain substances. To enhance consumers' and producers' information about the ingredients of food products, some countries require labeling, resulting in a product-attribute standard. Also packaging requirements can result in a product standard if they affect product characteristics such as freshness or if they contribute to increase the value added of the product.

On the contrary, process standards are requirements on the production process of agri-food products. They can be product related or non-product related. Product related process standards regulate inputs or ingredients handling. For example they prohibit the mixing of certain inputs considered incoherent with the overall quality of a product, imposing identity preservation or traceability requirements. Moreover, some pest management strategy and hygiene or sanitary measures in the transformation processes could directly affect the product safety.

Table 1.1: Product and process standards in the agri-food sector.

Type	Target	Exanples
Product standards	Maximum, Minimum level or ban	Chemicals and drug residues, additives and contaminants, fat and proteins content
	Packaging	Size, material and treatment of material
	Grading/classification	Wheat, meat or fruit classes
	Labeling	Ingredients or other labels
Process standards	Product-related	Inputs requirements (GMO, hormone)
		Handling and storage requirements
		Hygene and sanitary requirements
		Pest controls measure
	Non product-related	Labour conditions
		Animal welfare
		Envrionmentally friendly and organic production
		Traceability
		Quality management and assurance systems (HACCP, ISO, GAP)

Source: Author elaboration on Korinek et al., 2008

Non-product related process standards involve direct and indirect effects of production processes on the environment and the society. This kind of standards usually do not affect directly the characteristics of the products themselves, but are referred to harmful effects that the production process might have on the environment or on weaker components of the society (e.g. child labor).

Given the classification of the most diffused standards on agri-food products, it's difficult to determine whether their application is due to protectionist purposes or to legitimate regulation for protecting consumers. Hillman (1991) defined standards as 'any governmental device or practice other than a tariff which directly impedes the entry of imports into a country and which discriminates against imports, but does not apply with equal force on domestic production or distribution'. Following this definition, standards are considered barriers to trade in substitution of tariffs.

Other authors (Baldwin, 1970; Mahé, 1997) pointed out that the term 'barrier' should not be applied, because in many cases standards are measures whose main objective is to correct market inefficiencies and that have only a secondary and accidental restrictive effect on trade. So, those regulations that have a trade restricting effect but that have an overall positive welfare effect should be considered NTMs instead of NTBs.

Following this principle, Fisher and Serra (2000) defined a standard 'as not protectionist if it corresponds to the standard that the social planer would use if all firms were domestic'. This definition permits to take into account the welfare-enhancing effect of a standard despite its negative externalities.

There are several evidences that standards affect international trade of agri-food products, either negatively (Anderson et al., 2004; Fischer and Serra, 2000) or positively (Tian, 2003; Marette and Beghin, 2010). On one hand standards can protect domestic producers from foreign competition: in some cases the imports of products that do not satisfy the standards are eliminated, and more generally requirements compliance may raise production costs due to the addition of compliance costs.

Compliance costs may arise because a firm must change its production process in order to comply with a standard. This can also reduce the output capability of the firm, affecting negatively the capacity of a firm to exploit economies of scale and hence average production costs will increase. In the same time, production process changes include costs associated with risk and uncertainty. Furthermore, compliance costs magnitude depend on the size of the firm. Typically they can be easily carried by big firms endowed with greater resources and technologies, while for small firms compliance costs could represent a large fraction of production costs.

The willingness to comply with standard requirements is not the only condition that influences firm's decision to get access in a market. As a matter of fact, a firm can either decide to comply with a determined standard to get access in a particular market or it may prefer to minimize production costs supplying markets with less restrictive regulations. Hence, the decision of a firm depends also on the design and enforcement of the standards distributed worldwide, so that the resulting impact on trade is due to the overall presence of standards on the global market.

On the other hand, standards promote products differentiation, giving consumers a wider range of products quality levels at different prices, creating market niches for those products that a certain share of consumers are willing to buy. Standards also reduce the information asymmetry problem between producers and consumers and between different stages of the production and retail chain.

Minimum quality standards reduce search costs for consumers and promote consumers' trust, thus increasing the demand. This higher demand can be fulfilled by foreign producers with a comparative advantage in comply with the regulation requirement. For example, foreign producers can be advantaged when they are more efficient to address consumption externalities by the standard (Marette and Beghin, 2007). In these cases standards are anti-protectionist.

Product heterogeneity in the presence of standard provides producers and consumers with a choice over product quality that might not exist previously, and this can alter the behavior of the economic agents. It's difficult to analyze welfare effects of these behavioral changes, because the standard' introduction changes the nature of the market and consequently its equilibrium. Regulation may transform a perfectly competitive, homogeneous good market into an imperfectly competitive differentiated product market.

Evidence from surveys suggested that standards can significantly act as barrier to trade. Fliess (2005) conducted a survey among OECD and non-OECD countries finding that standards represent a major concern for exporters both in developing and developed countries. Otsuki (2004) goes further, finding that firms of medium size in developing countries consider burdensome to comply with import standards of developed countries.

Another important issue on agri-food standards is the international harmonization effort and the derived expected gains. Standards can be set unilaterally by a single country or multilaterally among a number of countries which find an agreement on the standard or that tend spontaneously to set similar regulations. Standard harmonization has been promoted by both governmental and international bodies. Both SPS and TBT agreements presume that standard harmonization does not constitute a barrier to trade because it permits a reduction of product or process adaptation costs for producers, it increases consumer trust by standardizing product characteristics and it reduces search costs for consumers (Moenius, 2006).

However, this beneficial view of harmonization does not take into account potential market access benefits of the standards. Harmonization causes a reduction of product diversification, reducing the choice between different quality level available to consumers, who may be forced to purchase products of a quality that they consider inferior. This means that if producers may save on adaption costs at the same time there is the risk that they lose product differentiation gains, hence harmonization is not a guarantee of trade promotion.

So far we showed the different impacts (positive or negative) that standards can have on the economy. We individuate impacts on market equilibrium, trade flows, economic efficiency and welfare. This is a first insight that suggests the difficulties to find a unified methodology in standards measurement and economic impact assessment, due to the heterogeneous nature of these regulations.

1.3 Methods for assessing the trade and welfare effects of standards

Assessment of the impact of standards on trade and welfare involves methods that belong to different fields of the economic literature. In this section we provide an overview of the most utilized methods in the assessment of the impact of NTBs on trade and welfare.

There are several reasons why measuring the economic impact of NTBs is important. First of all, a better knowledge of their effects responds to needs of policymakers during decision making processes. Second, providing an assessment of actual effects of NTBs to policymakers is necessary in order to address the role of these regulations in future trade agreements. Third, quantitative analysis informs governments about the costs that their regulations induce and represent a tool to define more efficient regulations. Moreover, the disposability of better techniques to estimate damage to trade partners caused by regulations are useful for solving disputes at international agreements level and for calculating compensations. Finally, several studies pointed out that NTBs set by developed countries represent obstacles to exports of developing countries.

To achieve these goals the measurements can focus on different economic features. One possibility is to measure NTBs effects on the volumes of goods traded at world prices. More generally, it is possible to account for the effects of NTBs on welfare. This is the most synthetic indicator for assessing the effects on the whole economy. Other measures can be calculated on the administrative enforcement costs and the resources lost to rent seeking.

Methods of measurement can be divided into two main groups: methods that estimate NTBs effects on trade and methods that estimate their effects on welfare (that take into account the different economic agents and effects on distribution). This distinction follows the well known uncertainty of impact of standards: on one hand they can boost trade by providing product information to consumers, on the other hand they may hamper international trade and discriminate between domestic and foreign producers. Moreover, standards differences across countries reflect different preferences of consumers and producers and risk perception.

Roberts *et al*. (1999) distinguished three effects on welfare: (i) a 'regulatory protection' effect which means that a regulation that provides rents to domestic producers discriminates foreign producers; (ii) a 'supply shift' effect, related to the effect of imports on the domestic supply and the compliance costs; (iii) a 'demand shift' effect, that takes into account that standards may bring information and increase consumer demand.

A further distinction is between methods for ex-post or ex-ante quantification of standards' impact. Ex-post analysis estimate changes in trade after observed introduction or redesigns of standards. Usually they are conducted by building frequency or coverage measures of standards or by using econometric models (e.g. gravity models). Ex-post analysis are frequently used to assess effects on trade.

On the contrary, ex-ante analysis are employed to predict in advance the likely impact of the introduction of a new NTB. They usually involve the calculation of tariff equivalents for effects on trade and partial or general equilibrium models for effects on welfare.

In table 2 we present a comprehensive overview of the methods for measuring standards' impacts on trade and welfare discussed in this chapter.

Table 1.2: Methods of estimation of standards' effect on trade and welfare.

<table>
<tr><th>Object of estimations</th><th colspan="2">Method or Approach</th></tr>
<tr><td rowspan="4">Effects on Trade</td><td>Price Wedge Method</td><td>Tariff Equivalent</td></tr>
<tr><td>Inventory Based Approach</td><td>Data on regulation, detentions or notifications
Frequency Ratio
Coverage Ratio</td></tr>
<tr><td colspan="2">Survey Based Approach</td></tr>
<tr><td>Econometric Models</td><td>Gravity Model</td></tr>
<tr><td rowspan="4">Effects on Welfare</td><td colspan="2">Risk Assessment</td></tr>
<tr><td colspan="2">Cost-Benefit Measures</td></tr>
<tr><td colspan="2">Stylized Microeconomic Approach</td></tr>
<tr><td>Sectoral and Multimarket Methods</td><td>Partial Equilibrium Models
General Equilibrium Models</td></tr>
</table>

Source: Author elaboration on Beghin and Bureau (2001) and Korinek et al. (2008).

Methods grounded in welfare economics, such as partial and general equilibrium analysis, capture a larger range of effects other than trade alone. They are conceptually superior, accounting also for externalities of the regulations, but in terms of multilateral negotiations their relevance is smaller. Indeed negotiators focus on trade distortions, measuring the impact as volumes of trade.

Despite the fact that several methods have been developed and exploited, it is still ambitious calculate an applied estimation of the effects of NTBs. Information on extra costs (administrative, fixed and compliance costs) induced by the regulation and price differences between foreign and domestic products are essential information for modeling, but often this information is incomplete. Furthermore, impact of standards on consumer' trust and willingness to pay is still uncertain. Even though advanced general equilibrium models are in theory able to capture complex effects of the regulations, in practice it is possible to obtain only simulation at aggregated level. Hence, the choice of the measurement strategy does not depend only on the analytical goal (focus on trade or welfare), but also and strongly on data availability.

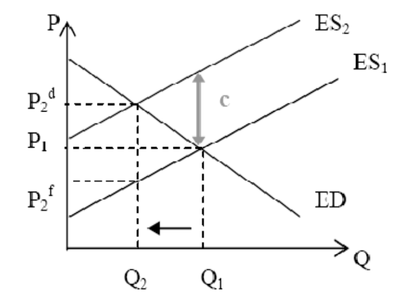
1.3.1 Price wedge method

This method is based on the principle that NTBs cause a restriction of imports, either directly (prohibitions or quotas) or indirectly (increasing transaction costs of trade), with the resultant raise of domestic prices in the importing country with respect to world prices. This difference of prices represent a price 'wedge' similar to that imposed by import tariff. Hence, in order to measure the impact of a standard, it is possible to calculate the magnitude of the price wedge.

Price-wedge methods are based on the idea that a NTB can be estimated in terms of its impact on the domestic price in comparison with a reference price. Correcting for other potential determinants of price differences unrelated with NTBs, such as transport and distribution costs or consumer' quality perception, this method provides the 'equivalent' tariff rate. With tariff equivalents it is possible to obtain comparisons of heterogeneous standards imposed by different countries.

Conceptually, a tariff equivalent reflects compliance costs, and this can be seen in figure 1. If the importing country sets a standard on a product (note that a single product can be subject to multiple standards and the calculation of a single tariff equivalent captures the aggregate effect of the applied standards) that result in compliance cost c, the supply curve ES shifts upwards from ES1 to ES2, where ES2 is equal to ES1+*c*. The compliance cost c constitutes a price wedge between domestic and foreign prices, that is the tariff equivalent of this standard calculated as P2*d*-P2*f* which results in a trade quantity Q2.

Figure 1.1: Quantifying the price wedge as a tariff equivalent.



Source: Korinek et al. (2008).

The tariff equivalent is usually calculated as the price difference between the imported good and the comparable domestic product, but theoretically, as Deardoff and Stern (1998) pointed out, the correct measure should be the comparison between the price that would prevail without the NTB and the domestic price in the presence of the NTB. However these prices are in most of the cases unavailable, so that the best calculation is the former adjusted for trading quantities and supply and demand elasticities of domestic and imported good.

One way of practical calculation is to compare the domestic price of the good with the invoice price paid to the exporter. The invoice price includes: bare cost of the good, insurance costs, transport and freight costs; but excludes tariffs. If this cost is not available, a solution is to use prices of different exporters, even though this strategy may display a biased price.

Despite the fact that tariff equivalent strategy is used typically to quantify trade impact of standards, the calculated price wedge can be used as an input for partial or general equilibrium model for welfare effects assessment of the standard.

The price wedge methodology has several limitations. The main limitation is the data availability for large scale studies.

Data are too aggregated impeding to register the differences in quality of imported goods. If domestic products are of higher quality reflected in a higher price, this method detects protection even if there is none or many other unwanted effects. Because of lack of data, the analysis can be conducted only on a few case studies, in particular those which concern similar products, but this is not the case for large-scale analysis. Moreover, the method allows to capture the effect of an aggregated set of standards, but it does not permit to discriminate what those NTB are precisely. Finally, some implicit calculation of the price wedges, for example the ones which provide a percentage price wedge between imported and domestic good prices, are possible only under the assumption that the goods are perfect substitutes. In this case there are biases related to prices: prices can be biased due to cross-country differences in supply and demand elasticities and prices can be affected by differences in ability of foreign and domestic firms to catch rents from non-tariff restriction. In the latter case, the price-wedge method will also reflect rents rather than NTBs effects.

Within the literature, particularly relevant are the studies of Calvin and Kristoff (1998) and European Commission (2001) in the use of tariff equivalent as an instrument to assess NTB trade impact.

Calvin and Kristoff (1998) estimated the tariff equivalent rate in the sector of apple, comparing invoice prices of exported U.S. apple in a foreign country with wholesale prices in the importing market. They assumed that the price wedge consists of tariff plus standard' tariff equivalent rates. Despite their effort to use like products, Calvin and Kristoff acknowledge that a small difference in apple quality between imported and domestic apple still exists. The same approach has been exploited by the European Commission in 2001 to compare invoice prices of imported U.S. pork and poultry meat and apples with the wholesale price in the EU market and to calculate the price wedge in percentage terms. While Calvin and Kristoff considered this approach as a valid one for estimating tariff equivalent of technical barriers, EU authors are more skeptical about the practical validity of this method.

1.3.2 Inventory based approach

This approaches are useful for assessing the trade impact of domestic regulation, both quantitatively and qualitatively, and are based on the use of simple indicators. A branch of data used to construct indicators are data on regulations (e.g. number of regulations, number of pages of the regulations), data on detentions at the border and data on complaints or notifications to international bodies.

It is expected that different standards show different effects on trade and the number of standards or the number of pages of the regulation per se is a weak proxy for the trade potential restrictiveness. Indeed, it is not clear if a direct correlation between the number of measures and the effect on trade exists. Moreover, without an effective enforcement it is unlikely that standards can affect trade or economic behavior.

Measures based on border detection are more reliable, but in this case problems on data availability arise. With the exception of the US and UE, countries tend not to provide this kind of information readily.

Frequency and coverage ratios are two indicators very diffused in the field of NTBs trade impact assessment. Frequency ratio is the number of product categories subject to an NTB as a percentage of the total number of product categories, while the import coverage ratio is computed as the value of imports of each commodity subject to an NTB as a percentage of all imports in the corresponding product category.

The underlying idea of the two indexes is that the greater the number of restrictions and the broader their application, the more likely is the restrictive impact on trade.

The great diffusion of frequency and coverage ratios is due to their computation simplicity. They can provide useful indications of the relevance of the problem and on which sectors and countries NTBs are more likely to be found, even though biases can arise for those standards that are trade improving and not trade hampering. Another source of bias concerns coverage ratio computation: it should be calculated using the total imports (in terms of value or volume) once NTBs are removed, but this kind of information is unobservable. An interesting attraction of these indicators is related to the possibility to include them as variables in econometric estimations. Moreover, they are the most readily available source of data on standards.

Examples of authors that used inventory based approach in the literature are Swann *et al.* (1996) and Moenius (1999), who have used counts of binding standards in a given industry as a measure of stringency of standards. Fontagné *et al.* (2001) assessed the potential use of environmental regulations as barriers to trade using frequency statistics. The underlying idea is that the lower the number of countries that adopt a certain standard, the greater the likelihood that the standard has protectionist purposes. Finally, Fontagné *et al.* (2005) calculate the import coverage ratio using the Trade Analysis Information System (TRAINS) database of the United Nations Conference on Trade and Development (UNCTAD) finding that NTBs applied for human health protection potentially affect 24% of world trade.

1.3.3 Survey based approaches

This approach allows to differentiate those regulations that have a major trade effect from those that do not, by asking stakeholders directly which are the measures with a greater impact on their activities. By using direct surveys, one can focus on the most relevant issues. They are particularly useful when other sources of basic information are lacking.

In the analysis of developing countries' willingness to export in developed countries, surveys combined with interviews have played a major role. This is because with surveys it is feasible to collect information and to identify those barriers that are diffused but difficult to detect and measure, such as administrative requirements.

Nevertheless, surveys can also provide biased information. In particular, questionnaire' definition and the way the survey is conducted could affect NTBs assessment. For example, this is the case when firms are the object of the survey and they have the perception that their responses could be used for policymaking purposes.

Because this method is very expensive, and taking into account that some form of biases can occur, it is suggested to restrict surveys to those cases where no other sources of information are available.

The United States Department of Agriculture (USDA) developed at the end of the last century a comprehensive cross-sectional dataset built on an extensive survey study on the trade impact of foreign technical regulations. The USDA dataset has been used in several studies (Roberts and DeRemer, 1997; Thornsbury, 1998; Thornsbury *et al.*, 1999), demonstrating the possibility of exploiting survey data in econometric analysis.

As a matter of the capability of surveys to catch sensitive issues related to NTBs of difficult detection, Henson *et al.* (2001) showed, through surveys coupled with interviews, that for European exporters to the US a source of major concern in terms of delays and lack of predictability are administrative burdens more than tariff and sanitary requirements. In the same way, OECD (1999) survey on dairy firms showed that only a few producers consider standards a source of concerns, but certification and approval delays represent a greater requirement to deal with.

1.3.4 Gravity based models

Econometric models are often used to assess ex-post the trade impact of standards and other regulations. Within econometric models, gravity models are more likely to provide information on the foregone trade not explained by tariff, because gravity model design is optimal to disentangle in the regression' residual the share due to the various bilateral trade flows determinants. Gravity models have traditionally been used to estimate 'home bias' and 'border effect' in trade, where a part of it reflects hamper effect of national regulations.

The basic gravity equation is derived from the Newton' 'Law of Universal Gravitation' (Head, 2000) which states that the attractive force between two objects i and j is directly proportional to the product of their mass and inversely proportional to their squared distance, given by:

$$F_{ij} = G\frac{M_i M_j}{D_{ij}^2}$$

Where F_{ij} represents the attractive force; M_i and M_j are the masses; D_{ij} is the distance between the two objects and G is a gravitational constant.

Intuitively, during the sixties Jan Tinbergen (1962) proposed to apply this functional form to trade flows, given by:

$$F_{ij} = R_j\frac{M_i^{\alpha} M_j^{\beta}}{D_{ij}^{\theta}}$$

Where F_{ij} is the trade flow (export or import) between countries i and j; M_i and M_j are the economic size of the two countries, usually represented by gross domestic products (GDP); D_{ij} is the distance between the two countries (usually measured center to center). R_j is the term 'remoteness' that represents the feasible alternative a country has to obtain commodities. For example countries that have nearby many sources of goods will have a high R_j.

The multiplicative nature of the gravity equation allows to take the natural logs, obtaining a linear relationship between the factors. The inclusion of an error term ε_{ij} permits, then, to obtain an equation that can be estimated by a simple ordinary least square (OLS) regression:

$$lnF_{ij} = \alpha lnM_i + \beta lnM_j - \theta lnD_{ij} + \rho \ln R_j + \in_{ij}$$

where the impact on bilateral trade is quantified by the coefficient on the standards regressor.

This relation can be augmented including other variables. Usually one includes the following standard gravity variables: language, common border and colonial relationships; recognized as having a significant role in affecting trade. Furthermore, in the analysis of the trade effect of NTBs, one can use information on regulations, such as the number of regulations, frequency and coverage ratios, survey-based information or level of standards themselves (e.g. level of chemical residuals or micotoxins).

Dummy variables are often used to indicate the existence or not of a standard, whether other forms of direct information are available or not. Despite the fact that dummy variables can reduce estimation biases due to omitted variables, they provide little information on the extent of the standard (Chevassus-Lozza *et al.*, 2005; Disdier and Fontagné, 2008).

Because countries tend to set and enforce different standards on the basis of their capacity of standard enforcement, in the gravity model it is possible to account and control for this differences by the inclusion of country fixed effects.

For a long time gravity models performed quite well but they lacked a theoretical foundation. Anderson (1979) gave a first theoretical foundation, followed by Bergstrand (1989), Deradorff (1998), Hummels (2000) and Anderson and Van Wincoop (2001). For an explained economic foundation of gravity model see Chapter 3.

Due to the specification of the gravity model, endogeneity is a significant problem. Indeed the direction of the causality between trade and standards is not clear, for example more trade can rise national income and shift consumer preferences to higher food quality standards. To deal with endogeneity problems it is possible to exploit instrumented variables, which are variables that explain standards but in the same time that do not affect bilateral trade. However, finding suitable instruments variables is difficult and not always possible.

One of the main limitations of gravity models, is the lack of time series data. Most of the studies in the literature tend to capture variations across products but not variation within products over time. The lack of time series data on standards impede, for example, to observe the capacity of an exporter to comply with regulatory changes of its trade partner or to cease exporting as a result of higher compliance costs.

Within the literature there are a number of studies that attempt to assess NTBs trade effect using gravity model. Moenius (2004) found a positive effect of bilateral shared standards across a sample of 471 industries (including agri-food sector) in 12 western OECD countries for the period 1985-1995. He stressed out that also country specific standards have a trade promoting effect, in particular exporter standards and importer standards in manufacturing industries (while the negative impact of importer standards in non-manufacturing sectors such as agriculture is confirmed).

Specific for the agri-food sector, Disdier *et al.* (2007) conducted an analysis on bilateral trade of 690 products at HS 6-digit level between importing OECD countries and 140 exporting countries. To capture NTBs effect they used different measures such as frequency ratio, dummy variables, ad-valorem tariff equivalents. For all three measures, they found a negative impact of the standards imposed by OECD countries on agri-food trade.

Another approach has been proposed by Otsuki *et al.* (2000) which used a direct measure of standard level, in particular of aflatoxins residues, as an explanatory variable, showing that European regulations on micotoxins represent a major barrier to African exports of dried fruits and nuts.

1.3.5 Risk assessment based and cost-benefit measures

The risk assessment and the cost-benefit approach are often coupled and indirectly contribute to provide a measurement of NTBs effects by a welfare estimation. Hence they do not provide a measurement of standards impact on trade as protectionist instrument, but they give indications on what should be included as barrier to trade.

This can be done by a comparison between compliance costs and gains associated to reduction of externalities. For example, the analysis of pest infestation or contaminations prevention strategies of a country can be used to better understand the efficiency or the protectionist effect of a domestic regulation.

The approach consists in decomposing the welfare effect of a regulation, assessing welfare losses associated to a standard in which costs exceeds benefits and disentangling the extent to which the standard can be qualified as a barrier to trade. When the benefits associated with the standard are found negligible, this approach provides a sufficient test of trade distortion.

Despite the fact that this approach is considered as one of the most interesting areas of research in the field of NTBs economic effects, its main limitation is due to the great uncertainty surrounding the possibility of a good assessment of risk levels and associated economic consequences. Moreover, it is difficult to quantify the consumer' willingness to pay for quality standards, in particular in those cases of scientifically unproven risks or ethical characteristics of goods.

Relevant studies that used this approach come from Bigsby and Whyte (2000) who applied in the case of pest infestation a measure of both economic effects and de facto probability of risk. Arrow *et al.* (1996) used a cost-benefit analysis to show that some health and environmental regulations costs exceed actual proven risk losses. Finally, Orden and Romano (1996) conducted an analysis on trade of avocados between the US and Mexico, mixing science-based evaluation and cost-benefit analysis in the assessment of legitimacy and protectionist effect of SPS measures. The analysis was based on risk evaluation of pests spread by avocado trade, the burden of measures to keep risk of pests spreading to low level and, finally, they conducted a combination of this assessments with an evaluation of potential costs to the benefits and impact on consumers. Because pest infestation reduces domestic supply and generates costs, hence increasing product price, a partial ban was tested. Results showed that a partial ban resulted in transfers to domestic producers in the US due to the higher price of the domestic product rather than the foreign one in order to save potential small costs of a pest infestation. This analysis resulted as a useful example of study for differentiating within the ban the protectionist issue from the legitimate pest avoidance component.

1.3.6 Stylized microeconomic approaches

This approach is based on the principle that the effect of an NTB can be assessed by looking at changes in market equilibrium induced by a new regulation. Effects of the regulation on the supply and demand functions can be measured given microeconomic data availability by standard computation of cost and profit functions as well as econometric estimation of utility and demand functions. The classical theoretical framework of price taking firms and perfectly informed consumers represents a valid foundation to assess the effects of regulations on supply and demand. Nevertheless, this theoretical framework makes drastic assumptions on the demand curve shape and on competition, resulting in difficulties for providing estimates of the various effects. In particular, it is difficult to calibrate the demand function for the demand of ethical or environmental attributes.

The best way to overcome this difficulties would be to include more sophisticated demand and supply equations with econometrically estimated parameters.

The main part of the literature dealing with this approach remained theoretical. Most of the studies investigated industrial economics with the goal to understand economic mechanisms rather than providing quantitative estimation of standards as NTBs. Strategic interactions between firms and reaction to new regulations has been investigated by Grossman and Horn (1989) and Crampes and Hollander (1995). Marette *et al.* (2000) studied how regulations modified information available to consumers, concluding that welfare effects of a regulation depend on the possibility for consumers to assess product quality and whether they can do it before or after consumption. Finally, Falvey (1989) showed that regulations may change costs of quality information for consumers.

1.3.7 Partial equilibrium models

Partial equilibrium models have been introduced by Marshal (1920) who based his approach on the principle that because economic problems are complex, therefore difficult to study and explain analytically, it is possible to decompose them in multiple easier problems. The strategy is to solve ceteris paribus each elementary problem and compose them taking into account mutual relations to obtain an overall view of the problem. Marshal's approach is in contraposition with the general equilibrium approach of Walras and Pareto, who provide a more exact view of the complex economic problem, even though with higher abstraction.

The partial equilibrium approach considers a one good market (or a market of a bunch of goods) and consumer expenditure is limited to the good with respect the total consumer' budget. Consequently, income effect will be small and effects on the overall market will be negligible as well as on welfare. Moreover, because we consider a small market, prices of other goods are not affected. Hence, taking into account only a small share of the market gives us a simplified assumption for equilibrium analysis.

Compared to gravity models, the main feature of partial equilibrium models is that they allow us to assess the impact of regulations both on trade and on welfare, providing quantitative results. Overton *et al.* (1995) showed that even a simple two market model partial equilibrium approach can provide useful estimation of SPS and TBT effects on trade and welfare.

The ceteris paribus condition represents also a source of limitation for these models. Indeed, markets are deeply interrelated and an isolated market does not fit with the real world. Globally, each market affects the equilibrium of the others, both from the demand and the supply side. Furthermore, another source of limitation is due to temporal specifications. Conditions of quantity and price changes in the short or in the long period.

Usually, partial equilibrium models are used to assess the effect of the introduction of a new regulation on the market equilibrium (e.g. prices, quantities and welfare). Different kind of partial equilibrium models exist: one country-one sector models, multi country-one sector models, one country-multi sector models and multi country-multi sector models.

Welfare changes are estimated through the analysis of consumers and producers surplus, often exploiting demand and supply elasticities provided by previous work in the literature. The main problem is to find a good proxy for the standards able to represent regulations into the mathematical model. One of the best choice is to adopt tariff equivalents.

Adoption of tariff equivalents in partial equilibrium models is relatively diffused in the literature. Krisoff *et al.* (1997) assessed the effect of SPS measures on apple in US exports to Japan, South Korea and Mexico. They estimate that the removal of the SPS requirements could increase US apple exports by about 23% in the period 1994-1996.

Noguira and Chouinard (2006) developed the same exercise showing that US apple exports to China could increase of about 21% while decrease of abou 0.8%. The difference is due to the different elasticities of import demand.

Finally, Peterson and Orden (2006) studied the SPS standards imposed on Mexican avocado exports by the US, modeling partial equilibrium with the compliance costs for Mexican producers and exporters by supply shift, showing that eliminating the restrictions will increase both the Mexican exports and the welfare in the US.

1.3.8 General equilibrium models

General equilibrium theory has been developed by Walras and Pareto in the same period of the partial equilibrium theory of Marshal. The fundamental difference consists in considering all variables as endogenous of the market, while exogenous variables as limited as possible.

An economy is represented as a closed economy with all the variables interrelated in equilibrium. Every time a change occurs, even partial, all the equilibrium conditions must be recalculated.

Following the definition of Mas-Colell *et al.* (1995), general equilibrium model 'is the theory of determination of equilibrium prices and quantities in a perfect competitive market'. Hence, general equilibrium models combine the economic theory with real market data to solve for demand, supply and price levels. The goal is to understand the impact of a regulation on the whole economy, often assessing transfer of endowments between and within sectors.

Deardoff and Stern (1985) stressed that to capture NTBs effects, a general equilibrium model must be multi country and multi good, so that a model that includes the greater number of countries using several parameters provides a level of simulation relatively close to the real world.

As in the partial equilibrium models, one of the main limitation in the general equilibrium approach is to find an appropriate parameter that is a good proxy for a complex regulation. Furthermore, because the goal is to estimate a multi country equilibrium, another limitation is to provide information on standards for each country, taking into account the modeling difficulties when standards vary significantly across countries.

Compared to partial equilibrium models, the general equilibrium approach is less diffused in the literature on NTBs effects assessment. Andriamanajara *et al.* (2004) insert a tariff equivalent variable in a general equilibrium model to assess the effect of the removal of NTBs on trade and welfare, finding that without standards international trade and welfare might increase. Moreover, this trade liberalization results in lower prices for consumers. With the same purpose, Kee *et al.* (2004) insert in a general equilibrium model the sum of tariff and tariff equivalents generated by NTBs to obtain the overall protectionist effect. Results showed that tariff equivalents increase trade protection by about 11-20%. Moreover, they find that in the agri-food sector NTBs levels are almost the double of those in the others sectors and high NTBs levels are associated with high tariff' rates suggesting that NTBs are a complementary and not a substitutive protectionist instrument. Finally Kee *et al.* (2004) found a positive correlation between NTBs and GDP per capita, suggesting a greater demand for high quality products in rich countries.

1.4 Private standards: classification and economic effects

So far we argued that food safety is essentially a 'public good' under the sovereignty of governments. Food safety is a basic requirement of any food system and externalities (or informational asymmetries) make the market itself unable to provide the socially desirable amount of safety. In this sense, governments provide standards to guarantee that food delivered to consumers is safe. Additionally to governments oversights, private control protocols developed rapidly in the food supply chain. They play an increasingly important role in the supply of higher quality food.

Private standards development is driven by slightly different reasons in comparison with public standards.

The presence of both private and public food standards result in a complex network in delivering quality products. While national regulation remains important, the private sector is increasingly taking the lead in shaping food global standards and this may mix forms of governance, where public and private regulatory systems coexist (Smith, 2009). As a result, development of public and private standards is mutually influenced and in certain points their requirements overlap.

Private standards are a relatively recent element in the food chain. Scope and characteristics differ widely across countries and food products. They mainly proliferated in industrialized countries in response to increasingly stringent regulatory requirements, reputational risks and liability exposure. Quality food standards shifted from 'public' to 'private' goods. As private goods, standards' main role is to increase product vertical differentiation.

Number of large multinational food retail chains, food service operators and food manufacturers decreased and ownership concentration increased in developed countries, where large firms are usually based. Multinational firms achieved stronger bargaining power to impose food standards to suppliers often based in less developed geographical areas. Hence, private standards diffused first in home countries and gradually in the rest of the globe, reaching middle and low-income countries (Fulponi, 2006).

Private standards continue to evolve in response to regulatory requirements and to consumer preferences and demand. Firms are able to meet market changes and differentiate their products refocus food and agricultural markets from price-based to quality-based competition. The role of private standards is supported both from the demand side, by demanding consumers in developed countries with varied tastes, and the supply side by production, processing and distribution technologies that allow product differentiation and market segmentation.

Private standards reflect, among other things, the level of industrialization and economic development, as well as national cultures and values. As a result heterogeneity among private standards is high. Private standards heterogeneity and their diffusion among national borders affect flows of commodities between countries, but also domestic production strategies and processes.

1.4.1 Evolution of private standards

The proliferation of private standards originated from a changing economic environment. We can highlight three main features bearing the development of private standards: the strengthening of consumer demands and expectations on food, the increased economic power of food retailers and the importance of information, quality and firm reputation.

With the evolution of lifestyles, demographics and increase of income, consumers focused on food safety, quality and method of production (Kinsey, 2001). Retailers are the last link in the agri-food chain. They are the most privileged agents to transfer new consumers' food expectations back through the food chain to producers and manufacturers, therefore retailers translated in new product and process standards consumers' demand. Consumer is the first driver of the food chain, finding in food retailers his main partner.

Retailers achieved in the 90s a greater consolidation and market concentration gaining bargaining power. Retailing now involves a limited number of firms and may be described as a form of monopolistic competition. This growth coupled with innovations and technological advances in information systems and transportation, including marketing and distribution systems, changed the food delivering sector dramatically. Competition in food retailing sector increased and larger firms acquired smaller ones. In the same time consumers obtained benefits in terms of lower prices and more variety.

Today about two thirds of consumed food passes through the retailer sector, where approximately the 60% of food is sold by large supermarkets in most OECD countries (Fulponi, 2006).

The increase of retailers' market size is explained also by the adoption of private label products which represent an important segment in retailers' earnings and are a tool to build trust and reputation. Private label products provide further incentives to develop private standards. Food retailers are no longer only distributors, but become players in food manufacturing in direct competition with firms of branded foods. As a result, prices of both private labels and branded products decrease.

Private labels became a direct signal of the manner of doing business of the retailers to consumers and, thus, intensified the need for controlling quality, safety and other attributes to prevent any risk to reputation. In this overall context the economic importance of information, quality and reputation is the major element that explains growth of private standards. As a result, consumer confidence raised as well as the demand and firms provide a signal of quality to reduce information gap.

Private standards extended from certification of product attributes to process ones. Chosen production strategies are monitored at key points to reduce risk and to remedy any failures rapidly. Process protocols include ISO 9000 (International Standard organization) for quality control, ISO 14000 for environment and SA 8000 (Social Accountability) for social conditions. The Codex Alimentarius recommended the adoption of the quality control system HACCP (Hazard Analysis and Critical Control Points) that has become the norm in the food sector. This management approach governs the entire production process monitoring for safety, quality or environmental attributes, both in food manufacturing and agriculture.

To verify the compliance with a given standard, firms use a combination of in-house and third party audits. Auditing and proofs of effectively enforced standards are essential to the credibility of the firm. Food safety management protocols, as well as specific standards for a given product, require specialized personnel to carry out the auditing and this renders certification and auditing difficult outside the home country, in particular in the countries lacking long-term experience in this area (Fulponi, 2006).

Because firms share concerns on food safety that are essential to their survival, they developed private coalitions for setting private standards in the food sector. The GFSI (Global Food Safety Initiatives) and the Eurep (Euro Retailer Produce Working Group) are private coalitions diffused worldwide. The GFSI's objective is food safety while Eurep is focused both on food safety and on good agricultural practices for sustainable agriculture. While firms continue to compete over quality, price, service and variety, they collaborate in a non-competitive way which could improve efficiency and reduce transaction costs by diminishing in-house inspections and multiple audits and certification.

Moreover, in order to strengthen relations between retailers and preferred suppliers or wholesalers, the use of private standards in the business to business (B2B) environment is increased. Most of this private standards are not directly communicated to consumers so they have a weaker role in product differentiation. The goal is to improve food chain efficiency. The B2B standards are expanding and they are achieving a greater role in Central and South America, Asia and Africa. Being linked to a large retailer, can represent for the supplier an economic benefit in terms of market access and also it can permit an upgrade in the production chain. This link is particularly relevant for developing countries as discussed in section 1.4.3. For example Eurep developed the EurepGap (Euro-retailer produce group and Good Agrucultural Practices) that essentially is a B2B scheme covering the areas of food safety, environmental protection, animal welfare and occupational health.

Private standards are based on the existing public standard infrastructure. The public minimum quality standard (MQS) provided the basis for an earlier quality differentiation of products and the subsequent private standards reflect prevailing national standards.

Furthermore, private standards evolved also as a consequence of changes in public standards in particular in their increasing stringency. Any changes in the public regulation encouraged private firms to continue to differentiate its product from the generic unbranded food that meet the public MQS, setting higher private food standard. This leads to a stronger link between public and private standards, where any changes in the public one is followed by modification in the private strategies of quality differentiation (Codron *et al.*, 2007).

In other cases, inadequate or unenforced public standards motivated the development of private strategies that acted as a substitute for missing or ineffective public regulation (Reardon *et al.*, 2001). This is the case of some developing countries where standards of multinational food firms have been applied at national level for local consumers (Reardon and Berdegeue, 2002).

1.4.2 Classification of private standards

Given the complexity of the food characteristics that private standards regulate, the different certification bodies involved and the different points of the agri-food chain to which they are applied, it is difficult provide a unique classification of private standards

A first important distinction is between:

- Legally-mandated private standards;
- Private voluntary standards

Legally-mandated private standards are set by private entities and adopted and enforced by governments as regulatory requirements. Under this principle, governments require firms to comply with particular standard by auto-controls. This is the example of HACCP in United States, Canada and European Union where the role of public authorities shifted from carrying out product inspection to checking that sellers of fresh agricultural products undertake their auto-controls correctly. For the public authority the delegation of quality controls to the sellers allows to extend the number and the coverage of quality controls and saving cost of public inspections for other sectors where risk may be higher. From the other side, sellers can share the cost of auto-controls with any laboratory at a preferential rate which permits economies of scale in implementing controls. If the auto-controls are correctly complied with, sellers are not considered responsible under criminal law for any quality anomaly.

Private voluntary standards are set and controlled by private entities. Particularly important is the GFSI, the first coalition of retailers in private standards setting. While EurepGap developed its own standard for primary production on food safety and environmental quality, GFSI has three major components but it has not developed its own standard scheme. The components are Good Agricultural Practice (GAP), Good Manufacturing Practice (GMP) and Good Distribution Practice (GDP). Taken all together, they create a complete food safety system from farm to fork, defining requirements for food safety, environment and labor. EurepGap is often used in sourcing from developing countries.

Another approach for distinguishing private standards is based on the entity who sets the standard. Within this strategy we can differentiate:

- Standards set by commercial or non-commercial entities;
- Collective or chain specific standards;
- Standards ordered according to the degree of producer autonomy in driving the standard.

Commercial entities could be companies, industries or associations, while usually non-commercial are Non Governmental Organizations (NGOs).

Collective standards are set by a group or association of companies (e.g. GlobalGAP) and chain specific standards are set by individual food companies (e.g. Tesco' Nature's Choice, Carrefour' Filière Qualité).

On the basis of the level of interdependency between production chain operators, from producers to buyers, we provide a classification of private standards in a continuum structure in figure 1.1 (Fulponi, 2006).

Fig. 1.1: Continuum of private voluntary standards ordered by degree of producer autonomy

The pure-producer standard is set, adopted and implemented by producers independently from downstream food companies. Examples of pure-producer standards are the Protected Designation of Origin (PDO) labels or organic food as part of producers' quality strategy. As the producer autonomy decreases we have a quasi-producer standard, developed by retailers, processors or manufactures in cooperation with producers. This can be either B2B or business to consumers (B2C) standards and audits are usually done by third parties with additional in house inspection. For example the SQF1000 (Safe Quality Food) was first initiated in Australia by producers who worked with food firms, it was then taken by a private firm and it is now e closer to retailers. Moving along the continuum line we find the pure-buyer standard developed by retailers, processors or manufacturers independently from producers consultation. This is a B2B standard, non communicated to consumers and it is not a direct marketing objective, but it is imposed to suppliers to reduce risks on food safety and reputation and to ensure quality. Examples of pure-buyer standards are EurepGap or retailer private label standards.

A further classification is based on standard attributes. Following this criteria we differentiate:

- Product and process standards;
- Standards to be implemented at different levels of the supply chain;

- Visibility of standards.

Product standards typically focus on the characteristic of product, while process standards focus on the production process, handling, processing, transport and distribution (Humphrey and Henson, 2008). An example of process standards are the requirements for organic farming. Genetically modified crops present both aspects. A product that contains GMOs can be labeled and GM production may require traceability systems and coexistence scheme. Standards can be applied at different stages along the agri-food chain. They can be required at farm-gate or production stage (GlobalGap) or can be manufacturing and distribution standards (HACCP). Finally, visibility of a standard is related to the communication of the standards to the consumers. B2C standards are developed by major retailers with the aim of building reputation and confidence, hence they are communicated to consumers, usually through a label. On the contrary B2B standards, that are used for product differentiation, are invisible to consumers.

The attributes most frequently covered by private standards are several. In the case of Food safety standards all firms have the aim to apply a zero tolerance to failures, so traceability is considered vital for the efficiency of the system. Several firms avoid developing countries as suppliers of meat or meat products because of food safety concerns.

Traditionally quality standards are those concerning taste, smell, texture and other gustative attributes. These characteristics, coupled with appearance and variety, are considered very important for firms' reputation. After food safety and quality, firms consider social and labor standards very important. The role of NGOs in monitoring firms raised social standards' importance. These standards are difficult to enforce outside the home country. For example, dealing with labor standards in developing countries is more difficult because of the lack of domestic labor laws. Other standards are those on animal welfare and the environment, even though less important than food safety, quality and labor conditions.

1.4.3 Economic effects of private standards

The numerous food safety emergencies that occurred in the 90s (e.g. swine flu, methanol wine) provided an incentive to food retailers to develop private standards and supply management systems which ensure the integrity, traceability, safety and quality of food. The move of the retailers activities in the field of food safety emerged also because consumers' confidence in government capacities to manage food risks decreased in Europe.

In general, private standards allow to achieve lower transaction costs, better management of supplies across wide geographical areas and standardization of product requirements over a range of suppliers (Henson and Reardon, 2005).

Agri-food firms still retain that government should be the responsible in setting minimum foods standards, but as a matter of fact they are more able and better equipped to fast react to food safety failures than regulatory authorities. A survey conducted by Fulponi (2006) among 16 retailers shows that retailers consider governments too cautious, cumbersome and not enough efficient to resolve urgent problems that can occur in food safety. Therefore, private food standards appear more flexible to react to changing consumer preferences than public ones. In spite of this, private and social interests are often distinct and an efficient private food control system may not yield socially efficient outcomes. The difference is that firms have incentives to provide high quality food in order to gain competitive advantage. From this prospective, to fully satisfy consumer needs of safety, public and private food standards tend to be complementary.

Public standards are still necessary to correct market failures due to information asymmetries and consumption externalities and where standards have clearly public good characteristics. Moreover, the dominant role of public standards still remains in establishing basic rules of food safety, grades for homogenous agricultural products to create economies of scale and to prevent fraud.

Private standards may play a substitutive role in absence of effective public standards and contribute to total system efficiency of national and global markets.

Because of this connection between public and private standards, a strategy adopted by private firms is to adopt standards above current or expected levels before governments set national regulation. In this case the regulator may be influenced to set lower MQS than they would otherwise have done, because, given that firms may have undertaken investments in terms of equipments or logistic to ensure their specific standards, governments might be unwilling to set standards that can raise firms costs. This is particularly true in those cases where there are consequences on employment or on prices. Such a pre-empting strategy may result in a reduction of social welfare compared to situations where government have moved first (Lutz *et al.*, 2000).

Retailers tend to adopt standards in function of the preferences of the consumers of the markets in which they operate. Most retailers would prefer to deal with one global food safety standard, because it may permit lower certification costs for suppliers and avoid to have different certification for each buyer. It also may permit retailers or buyers to switch suppliers and source around the globe more easily.

Certification processes and auditing are another area where retailers and suppliers would like to reach harmonization, because if what an auditor certifies in country A is certified in the same way in country B, this would raise the system efficiency.

Despite the fact that a global food standards does not yet exist, several private standards schemes are becoming global as the food system becomes interlinked worldwide. This could permit greater co-ordination of production and distribution across the globe, facilitating economies of scale and efficiency gains.

Private standards can have consistent effects on international trade. Jaffee and Henson (2004) argued that if the regulatory process commits member states to notify all food quality standards giving the opportunity for trade partners to raise concerns in an open dialogue, this does not apply to private standards, so the growth in private (collective) standards may raise the issue of the implication of the WTO and SPS and TBT agreements.

Private standards may impose significant compliance costs. To comply with the private standard, the supplier put in place fixed investments for production and processing facilities adjustment. Furthermore, they face personnel and management costs to enforce the standard and the control system and costs of conformity assessments. These costs are typically faced by exporters and, because a voluntary standard can differ across countries, complying costs can represent effective barriers to trade.

On the contrary, for those exporters able to comply with private standards, they represent a key issue to get access to the global value chain or they are determinant for retailer or manufacturers market access. Thus, private standards may have a catalytic effect in opening opportunities for such exporters.

There are evidences that WTO reduction of trade barriers itself may not facilitate market entry. Exporters or suppliers product also have to meet the requirements of leading firms in industrialized economies (Gereffi, 1999; Balsevich *et al.*, 2003; Berdegué *et al.*, 2004). This is because leading firms tend to deal only with well established suppliers able to provide proper quality products.

As a result, despite the fact that private standards are voluntary, they are applied by the majority of suppliers. So they become de facto mandatory: suppliers have little option but to comply with firm' standards in order to enter (remain) in a market controlled buy a few large buyers with oligopolistic power.

Large buyers, manufacturers and retailers traditionally have their home country in economically developed areas, so developing countries are the most affected by private standards requirements. Developing countries have to satisfy rich countries standards to export products in those markets.

First of all we saw that private standards can act as non-tariff barriers to trade, reducing export opportunities of the poorest countries which face multiple constrains in complying with stringent standards. From one side smallholder producers may result excluded from high-standard supply chains because of their inability to comply with high standards. This is because investments to meet the standards are too costly given the size of the producer and the expected revenues. From the other side smallholders may be exploited by the high-standard supply chain because of their lower bargaining. The non conformity with standards may be use as an argument by buyers to pay lower prices.

Standards may, thus, provide a bridge between producers in developing countries and consumer preferences in high-income markets. Furthermore, they may represent useful catalyst for modernization of developing countries' food chain improving their competitiveness (Maertens and Swinnen, 2007). Private standards may induce a restructure of the supply chain, shifting from smallholders contract-farming to large-scale agro-industrial farming, resulting in higher vertical coordination between large firms and small producers. The company often provides to the farmer production inputs (e.g. chemical application, management and technology assistance) and elaborates systems of on-farming monitoring permitting the farmer to supply a product with the required standard. Maertens and Swinnen (2009) showed that private standards in the Senegalese French bean production improved the restructuring of the supply chain, resulting in an increase of total household income.

Chapter 2

An Index of GMO Regulations and its Determinants

2.1 Introduction

In the previous chapter we discussed an overview of the methods for the evaluation of standards' effects on trade and welfare. A major issue is the difficulty to find a proper method of assessment given the heterogeneous nature of regulations. In this chapter we provide a strategy for assessing standards' effect on the international trade of agricultural and food products. In order to overcome measurement problems of the effect of genetically modified organisms (GMO) standards as NTBs instruments of protection, we build an original index of GMO regulation.
In the last fifteen years GM products became a major issue of trade disputes, both at bilateral and international levels (Disdiér *et al.*, 2008). In particular, we have been assisting to the opposition between exporters (producers) of agricultural commodities and importers (consumers), in a context in

which demand for agricultural and food goods has been increasing. Consumers, as well as green organizations in rich importing countries, raise worries on the safety of the food produced with this new technology (Gruére *et al.*, 2009). Regulators in this countries have responded by enforcing standards to ensure the safety of these products. In the same time, these standards may have an effect on trade.

As a result, worldwide GMO regulatory landscape is more and more heterogeneous, opposing countries with soft GMO standards (exporters) against countries with more stringent GMO standards (importers).

Following Ginarte and Park (1997), we build an index of GMO regulations for 60 countries distributed over all continents. The index is composed of six regulatory dimensions taking into account major features of GMO regulation, namely approval process, risk assessment, labeling policies, traceability system, coexistence management and membership in international agreements.

Furthermore, a branch of the literature pointed out that the convergence to similar standards between countries may boost trade (Tothova and Ohemke, 2004; Baier and Bergstrand, 2007). The argument is that harmonized regulations can act similarly to free trade sub-agreements, creating groups of countries in which goods exchanges are higher. A reason is that foreign producers which comply with trade partners standards may face lower production and transaction costs due to the same requirements.

The global environment regulation are thus set taking a complex net of relationships into account. Bilateral trade as well as other political, social and economic differences between countries contribute to determine food standards setting.

We deal with this aspects for two main reasons. First, we want to check the suitability of the index and its capability to measure differences in GMO standards. Second, we want to investigate determinants of differences in GMO regulation across countries.

To achieve these goals, we structured the chapter as follows: in section 2.2 we provide an index of GMO regulation explaining its components; in section 2.3 we test the index empirically; in section 2.4 we provide results and discussion on the determinants of differences in GMO regulations. Section 2.5 concludes.

2.2 An index of GMO regulation

2.2.1 Sample, data and computational strategy

We build our GMO index for 60 countries for which has been possible to collect information on laws and acts regulating GMO cultivation and commercialization. We collect available information on GMO regulations until June 2008, so that the large fraction of GMO standards considered was in place in the year 2007, or before. However, it is important to keep in mind that, especially for some developing countries, there could be significant delays in the regulation enforcement, due to both political and technical reasons. Thus, the relative GMO restrictiveness ranking for some developing countries could be slight bias up-ward (see below).

The considered countries include most EU countries and OECD members, important exporters of agricultural goods like Argentina, Brazil, China, India, Ukraine and Asian countries, important producers like Bangladesh, Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam. Moreover we also included Chile, Colombia, Guatemala, Israel, Jamaica, Peru, Russia, Saudi Arabia, Venezuela and some African countries: Kenya, South Africa, Zambia, and Zimbabwe (Table 2.1, gives the full list of countries considered). The criteria for choosing the countries was based on both their economic relevance in the agricultural international markets, as well as sufficient availability information related to laws and acts regulating GMO cultivation and commercialization.

The main information source used to classify the GMO regulations is the 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 refer to official national acts, reports or essays.

Six categories of GMO production and commercialization regulations were considered:

1. Approval process;
2. Risk assessment;
3. Labeling policies;
4. Traceability system;
5. Coexistence management;
6. Membership in international agreements GMO related.

Each GMO regulatory dimension was scored with values ranging from 0 (first condition) to the total number of conditions identified for each category (description of categories and conditions are discussed below). Higher scores indicate an increasing restrictiveness of the regulation. For example, for those countries that declare themselves to be 'GM free', which means that no GM products can be cultivated domestically or introduced, the highest score is assumed.

The overall GMO index is then obtained by the summation of each normalized scores sub-component – each score component being normalized to vary between 0 and 1. The final GMO index, after further normalization, can take on any value between 0 and 1, with higher values indicating a more complex national regulation on GMO production and commercialization, which suggests increasing restrictions to cultivation and trade.

Stringent regulations generally require more expansive procedures for exporters, and comprehensive policies can have a greater trade effect. It is assumed that approval procedures represent fixed costs, traceability and labeling variable costs, influencing present and future GM and non-GM crop exports (see Gruére, 2006).

Table 2.1 Categories, conditions and relative score of the GMO regulatory index

1.	**Approval process**	**Score**
	Lack of rules or ambiguous situations that do not put constraints on the cultivation and marketing	0
	Mandatory approval process, established at legislative level but still far from implementation	1
	Mandatory approval process in accordance with the principle of substantial equivalence	2
	Mandatory approval process under the precautionary principle including products derived from GM crops	3
	Countries declared GM free, prohibiting cultivation and marketing	4
2.	**Risk assessment**	**Score**
	There is no implementation of risk analysis	0
	The necessity of a risk assessment is at proposal stage	1
	Mandatory risk assessment	2
	Countries declared GM free	3
3.	**Labeling policies**	**Score**
	It is not required a label or is just at proposal stage	0
	Voluntary GMO labelling	1
	Mandatory GMO label without threshold or with threshold >= 5%	2
	Mandatory GMO label with threshold <= 1%	3
	Countries declared GM free	4
4.	**Traceability requirements**	**Score**
	It is not required a GMO traceability process or an IP system	0
	GMO traceability process is at proposal stage, or is in place an IP system	1
	Mandatory GMO traceability	2
	Countries declared GM free	3
5.	**Coexistence guidelines**	**Score**
	No coexistence rules have been introduced	0
	GMO coexistence policies at embryonic stage	1
	Partial guidelines on GMO and non-GMO coexistence	2
	Exhaustive guidelines on GMO coexistence	3
	Countries declared GM free	4
6.	**Membership in international agreements**	**Score**
	No adherence to international agreements	0
	Adherence to a single international agreement	1
	Adherence to both international agreements	2

Note: see text.

Some categories are strongly related to each other. For example, in many regulations an approval process cannot be conducted without a product risk assessment. However, this logic does not apply systematically to the GMO standards context. The analysis of 60 country policies suggests many unexpected and ambiguous stages of implementation. For example, there are countries which require a mandatory approval process but the risk analysis is under the responsibility of the importer (e.g. EU countries), and countries with a voluntary labeling regime but with no required traceability or segregation system (e.g. Canada).

An overview of the GMO index ranking and score is given in Table 2.2. Several interesting patterns emerge. First, as expected, there is the well known polarization between the US and the EU countries. The former has a GMO regulatory index of 0.35, which contrasts with the EU average of 0.69. Secondly, with the exception of Zambia and Zimbabwe, which declared to be both GMO-free countries, developing countries tend to be positioned in the low part of the ranking. All the considered EU countries, as well as food importers like Japan (but not South Korea), displayed a high GMO index. However, it is interesting to note that also within the EU there exist some differences in the GMO score. For example, the highest score of 0.75 was found for countries like Austria and Italy that have imposed a ban on the cultivation of EU approved GMO maize. Differently, EU countries like Spain and Germany have significantly lower scores, equal to 0.60 and 0.65, respectively.

The next sections justify and discuss in details how each regulatory dimension of the GMO index has been classified (by a score) and considered.

2.2.2 Approval process

The first condition that allows any possible handling of a GMO product is its approved status in a country. In contrast with the majority of conventional commodities, GM foods need specific approval procedures, both for import and cultivation, related to safety issues that are managed in different ways among countries: from a very comprehensive pathway including assessment of effect on mammals to, in several countries, a complete ban.

Table 2.2: GMO regulatory index score and ranking

	Rank	Country Code	Country	Index Value
1	1	ZMB	Zambia	1.00
2	1	ZWE	Zimbabwe	1.00
3	2	AUT	Austria	0.75
4	2	BEL	Belgium	0.75
5	2	CZE	Czech Republic	0.75
6	2	DNK	Denmark	0.75
7	2	FRA	France	0.75
8	2	HUN	Hungary	0.75
9	2	ITA	Italy	0.75
10	2	NLD	Netherlands	0.75
11	2	PRT	Portugal	0.75
12	3	EST	Estonia	0.70
13	3	FIN	Finland	0.70
14	3	JPN	Japan	0.70
15	4	EUN	European Union	0.69
16	5	DEU	Germany	0.65
17	5	GRC	Greece	0.65
18	5	IRL	Ireland	0.65
19	5	LUX	Luxembourg	0.65
20	5	NZL	New Zealand	0.65
21	5	ROM	Romania	0.65
22	5	SVK	Slovak Republic	0.65
23	5	SVN	Slovenia	0.65
24	5	SWE	Sweden	0.65
25	6	NOR	Norway	0.60
26	6	POL	Poland	0.60
27	6	ESP	Spain	0.60
28	6	GBR	United Kingdom	0.60
29	7	AUS	Australia	0.55
30	7	CHE	Switzerland	0.55
31	8	BRA	Brazil	0.50
32	8	CHN	China	0.50
33	9	COL	Colombia	0.45
34	9	KOR	Korea, Rep.	0.45
35	9	RUS	Russian Federation	0.45
36	9	SAU	Saudi Arabia	0.45
37	10	ARG	Argentina	0.40
38	10	THA	Thailand	0.40
39	11	CHL	Chile	0.35
40	11	IND	India	0.35
41	11	IDN	Indonesia	0.35
42	11	MYS	Malaysia	0.35
43	11	MEX	Mexico	0.35
44	11	USA	United States	0.35
45	12	CAN	Canada	0.30
46	12	GTM	Guatemala	0.30
47	12	PHL	Philippines	0.30
48	12	SGP	Singapore	0.30
49	12	ZAF	South Africa	0.30
50	12	TWN	Taiwan, China	0.30
51	12	VNM	Vietnam	0.30
52	13	ISR	Israel	0.20
53	13	JAM	Jamaica	0.20
54	13	KEN	Kenya	0.20
55	14	BGD	Bangladesh	0.15
56	14	PER	Peru	0.15
57	14	LKA	Sri Lanka	0.15
58	14	TUR	Turkey	0.15
59	14	UKR	Ukraine	0.15
60	14	VEN	Venezuela	0.15
61	15	HKG	Hong Kong, China	0.10

Notes: Mean = 0.50; Standard Deviation = 0.226

In contrast with requirements like traceability and labeling, which act similarly to trade standards, import approval for a GM food is a measure directly affecting market access: if a GM event is not approved it is not possible to introduce it in the country.

The requirements for an approval process vary widely across countries. There are two main groups of countries which share similar approaches. One follows the EU regulations, based on the 'precautionary principle', which means that any product produced with, or derived from, transgenic crops is subject to GM regulations and the consumers' 'right to know'. The second group follows the US attitude of 'substantial equivalence', which exempts for essentially equivalent products any specific requirements (Gruére, 2006). Between the two groups there are many different approaches to the approval process.

We defined five levels of restrictiveness (from 0 to 4) of approval processes based on the degree of domestic implementation of the regulation. A score of 0 is given when there are no constraints on GMO cultivation and marketing; a score of 1 if there exists a mandatory approval process established at the legislative level, but not yet implemented; a score of 2 when the mandatory approval process follows the principle of substantial equivalence; a score of 3 when a mandatory approval process follows the precautionary principle; finally a score of 4 in situations of GMO free status (prohibition of cultivation and marketing, see Table 2.1).

Most EU members, Japan and fast-growing income countries like China and India are scored in the third condition, which is the most comprehensive. The zero or first conditions include developing or emerging countries, which take what is called a 'wait and see' position with respect to the international polarization led by the EU and US.

2.2.3 Risk assessment

Assessments are based on the biological characteristics of the new organism, and test the safety of food, fodder and the environment. Authorization depends on a positive risk assessment, usually conducted by an independent body that establishes standards for testing and detection. The typology of the testing depends on the country's approach, whether based on substantial equivalent or precautionary principle. In many cases the exporter is the legal subject responsible for the assessment.

On the international scenario biosafety assessment is gaining importance, being the target for international harmonization efforts for setting a common methodology, though still at the discussion stage. Biosafety assessment requires deeper analysis through the adoption of field trials. Indeed, for those countries possessing native plants, testing of potential gene flow from GM crops to their wild (native) relatives is needed. The scheduling and realization of programs for field trials is expensive and some countries (e.g. developing countries) are not able to deal with these costs.

We identified a scoring classification of requirement levels (range 0-3) for a national risk assessment regulation. The conditions scoring 0 and 3 indicate a lack in the risk assessment framework, but the differences are substantial: a score of 0 (e.g. Ukraine) means a normative void that does not affect trade or cultivation as there are no standards; score 3, on the contrary, applies to countries declaring themselves 'GMO free', hence totally opposed to the importation (and cultivation) of GMOs and imposing the strongest degree of regulation restrictiveness. Between these two scores, we have 1 if the risk assessment is at a regulation proposal stage, and 2 if risk assessment is compulsory.

2.2.4 Labeling policies

In 1997, the EU introduced GMO labeling policies with the purpose of guaranteeing 'the consumer's right to know', but labels carry indications other than just the presence of GM ingredients, they also give information on health factors and product diversification (Veyssiere and Giannakas, 2004). Labeling has also met environmental issues, playing a role in consumption decisions of consumers concerned by environmental factors associated with GM products (Appleton, 2000). Indeed, a label can act as a warning, indicating potential hazards and thus affecting the demand for GM and non-GM products, particularly reducing the demand for the former (Gruère, 2006).

Over the past ten years, an increasing number of countries have become involved with labeling requirements, and all have different regulation characteristics (see Gruère and Rao, 2007). We have identified five categories of labeling characteristics, where thresholds play a fundamental role as a specific standard for trade issues. Compliance with a restrictive threshold implies an increase in production and commercialization costs.

The possibility of labeling is strictly related to segregation, identity preservation (IP) and traceability system, that can be considered alternative methods for differentiation. Even though IP is currently used to identify crop varieties in some countries (e.g. US and South Africa) permitting exports in countries with a mandatory labeling regime, it could represent a first step for traceability and coexistence. Hence, we focus on traceability system as a market mechanism to accommodate differences in labeling requirements. Though labeling and traceability represent two separate categories, several country's policies consider the two related.

A labeling regime is expected to influence trade flows, and, in particular, to affect the trade of the chief suppliers of GM crops (Gruère and Rao, 2007; Gruère *et al.*, 2009). Costs caused by a labeling regime depend on: the threshold level, the capacity of the public authority to enforce labeling requirements, and the capacity of industry to comply with labeling rules. GM labels have effects on the whole agri-food chain. Actors have to collect and handle information concerning the presence of GM food components until reaching the final consumer, but the transfer of this information adds onerous management costs. Ultimately, labeling indirectly affects trade through the imposition of implementation costs for GM crop exporters.

Among countries we registered two main attitudes: voluntary and mandatory labeling regimes. Mandatory labeling requirements are divided into further two groups: label on the finished product (Australia and Japan), and on GM technology as a production process (EU and China). In the former case, the quantification of GM ingredients is required to be labeled, and, usually, the threshold is higher. In the latter case any product derived from GM crops has to be reported. In this case, thresholds decrease in entity and the process based system directly requires the exporters to have a form of identity preservation or a traceability system.

Labeling categories are scored from 0 to 5. We have a 0 score in the absence of labeling requirements; 1 with voluntary regime; 2 in the presence of a mandatory regime with a threshold equal or higher than 5%; 3 with mandatory regime but with a threshold equal or lower than 1%; and, finally, 4 in countries that declare themselves GM free.

2.2.5 Traceability requirements

Traceability is an instrument to create a network able to 'retrace history, use, or location of an entity by means of recorded identification', and that guarantees efficient withdrawal from the food and feed market if any unexpected effects occurs to mammalian health and the environment. In the case of GMO products, the traceability system is based on IP for the diversification between different productions, ensuring to the consumer the origin and the typology of the product. Moreover, producers, processors and retailers of food have to collect, retain and transmit information in each stage of the agri-food chain (Bailey, 2002).

Countries with a comprehensive traceability regulation must create procedures for the identification of industry chain participants who supply and demand products. Actors of the food chain must transmit information on the identity of the product and whether it contains GMOs, retain such information for a long period (post-market monitoring), i.e. 5 years, and guarantee its availability for applicants (Wilson *et al.*, 2008).

At the producer level, farmers have to be certain of the absence of cross-pollination between neighboring crops, and must comply with certified storage and harvesting. Elevators, processors and retailers must keep information on product identity and transmit this information by lot numbers and test results.

All these requirements induce increasing costs, but also benefit the market niche gains. Cost increase is difficult to establish because traceability is an issue with long term implications, with variable costs depending on crops, e.g. soya and maize provide a great number of byproducts in different agri-food industries. Moreover, liability and compensation schemes are crucial. The main costs are referred to certification, record collection and information keeping, and are carried by GMO producers and suppliers countries, with a potentially higher final market price, for both GMO and GMO-free products.

For the traceability category we define the following scores: 0 if the regulation does not require a traceability or an IP system; 1 if the traceability requirement is at the proposal stage or if it is implemented an IP system; 2 if traceability is mandatory; and 3 if the country is GM free.

2.2.6 Coexistence guidelines

The purpose of managing coexistence is to guarantee to consumers and farmers the possibility of choosing what to consume or produce among GM, traditional and organic products. This is feasible only if there is the preservation of identity among crops, which must be segregated in space and time. Thus it is not possible to cultivate nearby fields of GM and organic crops, or to manage them in short rotations. Coexistence managing procedures require mechanisms preventing pollen flows (such as distances or pollen barriers between fields of GM, traditional and organic products), refuges areas and dedicated machineries, but also compensation and liability systems. It also requires strong cooperation between farmers in close proximity.

Production costs in a coexistence scenario arise due to isolation costs, monitoring, purity testing, dedicated equipment and/or its cleaning, which can vary at the establish purity levels, taking into account that zero threshold of transgene in GMO-free crops is not feasible in some agricultural systems. Some developing country policy makers assume that coexistence is not feasible or can be done only by facing prohibitive costs.

Because of the difficulties in establishing coexistence strategies, the level of implementation of coexistence policies varies widely across countries, and in several cases requirements are not stated clearly. For this reason we decided to score 0 those countries without any coexistence rule, 1 if coexistence policies are at embryonic stage, 2 if partial guidelines were prepared, 3 if exhaustive coexistence guidelines are adopted and 4 if the country is GM free.

2.2.7 Membership in international GMO related agreements

We considered two institutions, the Codex Alimentarius and the Cartagena Protocol on Biosafety, which, among several international agreements, have effects on the trading of biotech products.

The Codex Alimentarius has the purpose of define standards to protect consumer health, and promoting fair relationship in international trade practices. It has successfully reached an agreement on safety assessment procedures for GMOs, but no formal labeling standards were adopted, these remaining a disagreed issue.

The aim of the Cartagena Protocol on Biosafety (BSP), part of the United Nation Convention on Biodiversity, is to introduce a shared procedure for risk assessment, risk management and trans-boundary movements of Living Modified Organisms (LMOs). The BSP acts between importers and exporters, introducing an Advanced Informed Agreement (AIA) for the intentional introduction of LMOs into the environment. In particular, it requires a comprehensive risk assessment and risk management framework provided by the exporter before the first introduction of any LMO in the importer territory.

Rules from the BSP are on bundling, transport, packaging and identification during any LMO trans-boundary movement. This comprehensive mechanism for the safe movement of LMOs was offered by the Cartagena Protocol on Biosafety as a primary policy for all those countries without domestic regulations, including liability rules for the illegal flow of LMOs, and calls for a ban of GM crop imports as a precautionary measure. The compliance with the BSP requirements could impose higher production and marketing costs on agricultural goods, both GM and non-GM, because of the institution of domestic structures for annual testing.

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

It is important to note that, Until the Codex Alimentarius Commission reaches an agreement on labeling, and BSP became active with the necessary testing structures in all member countries, neither of the two international institutions will influence trade flows. However, we decide to consider also this index category on the ground that expected future enforcement could have an effect on actual trade.

2.3 Data and model specification

Dependent variables

In order to investigate the determinants of the differences in GMOs regulation across countries, we calculated bilateral measures of the GMO index. We used two different measures of the bilateral index to increase the likelihood of our findings on the determinants of differences in regulation.

Both measures are similarity indexes. The first, called GMOwij, is based on the similarity index recently proposed by Anderson (2009) and based on the approach earlier introduced by Jaffe (1986). The index can be defined as follow:

$$GMOw_{ij} = \frac{\sum_{m=1}^{M} f_{im} f_{jm}}{\left(\sum_{m=1}^{M} f_{im}^{2}\right)^{1/2} \left(\sum_{m=1}^{M} f_{jm}^{2}\right)^{1/2}}$$

Where fim is the ratio between the regulatory dimension score attributed to country i on the highest score assigned to the regulatory dimension m. This allow us to obtain a degree of bilateral regulatory 'closeness' between two countries, ranging between 0 (completely different) and 1 (identical regulation). In other words, this index defines vectors of national rationed score, named *fi* = (*fi*1,…, *fiM*) with *M* = 1, ... 6, which locates country *i* in the M-dimensional space. Similarity of the regulation can be computed through the proximity of the f-vectors, defined by the cosine of the angle between them. Jaffe (1989) indicate that proximity measures is 0 for countries whose vectors are orthogonal and 1 for countries whose position vectors are identical.

This GMOwij have several useful properties for measuring similarity. Indeed, it is conceptually similar to a correlation coefficient, and as such have the property to be completely symmetric.

The second bilateral index, called $GMOd_{ij}$, is equal to 1 minus the absolute deviation of our GMO index across country pairs, namely $GMOd_{ij} = 1 - |GMOi - GMOj|$. Thus the $GMOd_{ij}$ bilateral index increases in the level of similarity or closeness in GMO regulations across country pairs. The correlation coefficient between $GMOd_{ij}$ and $GMOw_{ij}$ is positive and equal to 0.59.

Explanatory Variables

Three different groups of potential explanatory variables are considered, namely trade costs, institutional difference and economic controls. Data has been collected for the 60 countries for which we calculated the GMO index.

We use four different variables to capture trade costs between countries: distance, common language, colonial links and bilateral tariffs.

Distance is calculated as the natural logarithm of distance between countries. Higher distance between two countries represent a significant increase in trade costs, as the large literature on the gravity model has strongly confirmed. Costs of transportation, costs related to damage, loss, decomposition of perishable goods, costs related to failure in synchronization between factories belonging to the same production chain, communication costs and transaction costs increase with the distance (Head, 2000). Distance is also a proxy of 'cultural distance'. Greater geographic distances are correlated with larger cultural differences. Cultural differences can impede trade in many ways such as inhibiting communication, generating misunderstandings, clashes in negotiation styles, etc. We expect that distance has a negative effect on similarity of GMO regulation. Indeed, it is likely that countries located in different geographical areas have comparative advantage in the production of different products due to climate differences. Hence they may set different standards according to crops produced and method of production. Moreover, cultural differences may lead to different GMO regulations.

Language and colonial links represent transaction costs related to inability to communicate and cultural differences (Head, 2000). We expect that countries that speak the same language would share similar regulations because the better communication and the consequently easier engagement in bilateral agreements. Colonial links explain the fact that two countries share a language through historical reasons. Including colonial links reduce the language effect. We expect that common language and colonial links have a positive effect on standards similarity given closer cultures and easier communication.

In the analysis we included tariffs related to four products, namely maize, soybean, rapeseed and cotton, as an average of ad-valorem tariff values. The four crops represent the greatest amount of GM products traded worldwide (James, 2009). Tariffs controls also for commercial agreements between countries. Indeed tariff is 0 for countries belonging to free trade areas (FTA). We calculated the tariff variable as $Log(1+tariff)_{ij}$. We expect that bilateral tariffs have a negative effect on the dependent variable. Country pairs with bilateral tariffs are not part of a FTA, hence regulation may be different. Moreover, NTBs may be complementary to tariff barriers, so it is likely that difference in standards occur where there are tariffs.

Data on distance, language and colony are taken from CEPII (Centre d'Etude Prospectives et d'Informations Internationales), while data on bilateral tariffs comes from the MAcMap database jointly developed by ITC (UNCTAD and WTO, Geneva) and CEPII (Paris).

We used three variables to capture institutional difference: an index of intellectual property rights (IPR index), health expenditure and a variable measuring the degree of democracy (Polity2).

We used the IPR index developed by Ginarte and Park (1997) updated to 2005 (Park, 2008). It is a composite index built on scored components. Categories that compose the index are products covered by patents, membership in international treaties, duration of protection, enforcement mechanism and restriction of patents right. Patent protection is a function of level of development of the country and of level of expenditure for research and development (R&D). Furthermore, it indicate the international integration of the country (Ginarte and Park, 1997). For the analysis we computed a bilateral IPR index as the absolute deviation between the index of two countries. Because it measure the difference in patent regulation, we expect that this variable shows a negative effect on the similarity in GMO regulation.

Health expenditure as a percentage of GDP has been included. Health expenditure is an important indicator of the level of development of the domestic health system and of the protection of the safety of population. Furthermore, it is directly proportional to the economic development of the country. We calculate the absolute deviation between the health expenditure of two countries. It is likely that an high difference in health expenditure has a negative effect on the similarity in GMO regulation. This because difference in health expenditure suggest different level in health protection that may be translated in different food safety standards.

Moreover, we considered differences in political institutions by adding the Polity2 index of democracy. This index varies from -10 (autocracy) to +10 (democracy) with higher values associated with better democracies. Countries based on a democratic political system provide greater representation of the population. Lobbing activities of green parties and consumers associations have an important role. Hence policymakers take into account citizens preferences in regulation setting. We rescaled the value of the index in the range from 0 (worse autocracy) to 20 (best democracy) to obtain positive values in calculating the absolute difference between the Polity2 of two countries. We expect that countries with different political systems set different GMO regulation. Thus, Polity2 variable should have a positive effect on GMO standards similarity.

The IPR index is taken from the paper of Park (2008). Data on health expenditure comes from the World Development Indicators (WDI) database developed by the World Bank, while the Polity2 variable is taken from the Polity IV database.

As economic controls, we used three variables: the gross domestic product (GDP), the per capita GDP and the bilateral trade.

GDP is a measure of economic size of a country. A country with an high GDP has a greater bargaining power in international agreements and has a greater importance in the global market. Hence, decisions taken from a country with a great economic size affect decisions of several other countries, in particular of business partners. We calculate the absolute deviation between the log of the GDP of two countries. It is expected that differences in GDP affect negatively the similarity in GMO regulation, because it is likely that countries with similar economic size have also similar bargaining power in international agreements.

The per capita GDP is a proxy of economic development of the country. Consumers in high income countries have greater demand for high quality products then in low income countries. We calculate the absolute deviation of the per capita GDP of two countries. It is expected that different levels of development show a negative effect on GMO regulation similarity, because it is likely that consumers in rich countries have similar preferences in food safety regulations..

We considered bilateral trade flows of four main crops involved in GMO: maize, soybean, rapeseed and cotton. Countries producers of GMOs are those with extensive agricultural systems and usually they are the most important exporters of agricultural commodities due to greater endowment in land. Adoption of GMOs result in a lower application of chemicals saving costs for applications. We expect that pair of countries with high trade flows share similar GMO regulation to reduce complying costs. Hence we expect that an high trade flow shows a positive effect on the dependent variable.

Data on GDP and per capita GDP come from the WDI World Bank' database. Trade data comes from the Commodity Trade of the United Nations Statistical Division database (UN-COMTRADE)

Moreover, we include also a dummy variable that control for European Union members (EU members), equal to 1 (0 otherwise) if both countries are part of the EU. This should permit to control for the specificity of the EU in terms of GMO regulations, trade and economic integration.

Finally, we included separated fixed effects, for each country considered in the bilateral relationship, χ_i and λ_j , to control for country heterogeneity and unobserved factors.

Econometrically we run OLS regressions, working both with a pooled and fixed effects specification. The general specification that links the similarity of GMO regulation between two countries and their potential determinants is shown in equation (2.1):

$$\begin{aligned} GMOij = \beta_0 + \chi_i + \lambda_j + \beta_1 \, ln\ distance + \beta_2 \, Common\ language + \\ \beta_3 \, Colonial\ links + \beta_4 \, ln\ (1{+}tariff)_{ij} + \beta_5 \, IPR\ index + \\ \beta_6 \, Health\ expenditure + \beta 7 \, Polity2 + \beta_8 \, ln\ GDP + \\ \beta_9 \, ln\ GDPpc + \beta_{10} \, ln\ Trade\ flows + \beta_{11} \, EU\ members + \varepsilon_{ij} \end{aligned} \tag{2.1}$$

Where β_0 is a common intercept, $\beta_1 - \beta_{11}$ are the coefficient to be estimated and ε_{ij} is an error term.

2.4 Results and discussion

We estimated the effect of trade costs, institutional differences and economic control variables on differences in GMO food standards across country pairs. The aim is to investigate which are the socio-economic determinants of harmonized GMO regulation.

Our strategy is to compare two different measures of GMO similarity index, using three different specifications of equation (2.1). We start with a pooled specification and then we include country fixed effects. Finally, we include fixed effects as well as a dummy variable for EU membership. The introduction of country fixed effects allows us to control for country heterogeneity and for unobserved factors, providing more robust results.

Table 2.1 reports results of equation (2.1) for the dependent variable $GMOw_{ij}$. In column (1) variables *Log distance*, *IPR index*, *Health Expenditure*, *GDPpc* and *Trade flows* are significant at the 1% level and have the expected sign. *Health Expenditure* displays a negative coefficient. Given that the higher the difference in health expenditure between two countries, the less GMO regulations are similar, a negative effect may suggest that countries with similar levels of health expenditure tend to share similar food regulations on GM products. In the same way, the high significance of *GDPpc* and its negative effect may suggest that small differences in economic development lead to similar GMO regulations. Trade flows display a positive coefficient, meaning that higher trade in food products across countries stimulate regulators to harmonize standards. Similar regulations can act as a trade sub-agreement, reducing compliance and transaction costs in a perspective of standards as an anti-protectionist tool (Tian, 2003; Tothova and Oehmke, 2004; Marette and Beghin, 2010). In column (1), GDP is highly significant and Polity2 is significant at the 10% level, but both are unexpectedly positive.

Passing to column (2) and (3) we included country fixed effects and country fixed effects plus *EU members* dummy respectively. Results for *Health expenditure*, *GDPpc* and *Trade flows* are confirmed. Nevertheless, some variables are no longer significant: *Log distance*, *IPR index*, *Polity2* and *GDP*.

It is important to note that in the fixed effects regression, most of the trade costs (*Common language*, *Colonial links* and *tariffs*) become significant at the 1% level. The negative effect of common language was expected and is consistent with the fact that same languages can promote similar regulations due to similar cultural backgrounds. Unexpectedly, colonial links have a negative effect on GMO standards harmonization. This result may suggest that after past common history and after WTO tariff reduction, there could exist a form of protectionism in GM products between countries and their past colonizers. Tariffs show a negative and strong effect on the harmonization of GMO regulations. This means that the more the tariffs are high, the less the countries set similar standards. The result is in different requirements in presence of high tariff rates. Indeed tariffs are imposed for protectionist purposes, so it is quite likely that importers that would protect their domestic firms adopt also NTBs. Furthermore, country pairs with high bilateral tariffs are not part of the same FTA. This suggest that the lack of agreements affect also standard setting. For example, both in tables 2.1 and 2.2, when controlling for EU membership, the magnitude of the coefficient of tariffs decreases, while it remains significant at the 1% level in presence of importer and exporter fixed effects.

Table 2.2 provides robustness checks results for the second similarity index as dependent variable. Overall, using the $GMOd_{ij}$ index we find an higher number of significant variables, although some of them change their estimated signs. Passing from column (1) to column (2) and (3) results are confirmed, with the exception of *GDP* which is significant only in the pooled specification. Variables related to *Colonial links*, *tariffs*, *Health expenditure* and *Trade flows* are fully confirmed from table 2.1.

Moreover, *Log distance* and *IPR index* are significant at 1% level in each regression specification of table 2.2. As expected distance has a negative impact on GMO regulation similarity. Countries geographically distant have low trade flows because of the increased costs, hence regulators have no incentive to promote trade through harmonization efforts. Furthermore, geographic distance as a proxy of cultural differences may suggest that consumers with different preferences induce regulators to set different standards. It is interesting to note the negative and highly significant effect of differences in patent regulations. Because the variable *IPR index* is calculated as the (absolute) difference between the value of IPR index of two countries, great differences in patent regulation affect similarity in GMO regulation. Hence, there is an accordance in regulations setting. Similar patent regulation may represent similar level of expenditure for R&D.

GDPpc is highly significant in the fixed effects regressions of columns (2) and (3). Nevertheless, despite *GDP* and *GDPpc* are significant, from the comparison with table 2.1 they show an opposite sign. Changes in signs may be due to the different measurement of the bilateral GMO index. $GMOw_{ij}$ is computed by the weight of each components of the regulation while $GMOd_{ij}$ is a simple difference between the index of two countries. In further investigation on the effect of the similarity of the GMO regulation on trade (see Chapter 3), we saw that components have different effects on bilateral trade. In particular, labeling, approval process and traceability affect trade more than other components. In some situation $GMOd_{ij}$ may not reflect the major role of the three components. This may affect the effect of *GDP* and *GDPpc*.

With country fixed effects the political variable Polity2 is a significant determinant of $GMOd_{ij}$. Its effect is positive and this may suggest that countries with different level of democracy have similar regulations. This can be the case for those developing countries governed by autocracy exporters to democratic developed countries. There are evidences that developing countries tend to adopt similar standards of their main trade partners to achieve or maintain access in rich markets (Gruére, 2006; Gruére and Rao, 2007).

From the comparison of the two different computation of the similarity GMO index, our results show that tariffs, health expenditure and trade flows are key determinants in the harmonization of GMO regulations. Tariffs emerge as a key explanatory variable in GMO standards harmonization, while results on distance, common language, IPR index and Polity2 appear sensitive on how we measure the GMOs index. Indeed they are not fully confirmed by the use of both dependent variables, but they seems to play a role in GMO standards harmonization.

Finally, results on colonial links, GDP and *per capita* GDP are not clear. Colonial links should display a positive effect and not negative, while GDP and *per capita* GDP effects seems very sensitive to the different measures of the GMO similarity index.

2.5 Conclusions

Motivated by the aim to find a strategy in the measurement of NTBs effects on trade, this chapter deals with the individuation of the socio-economic determinants of similarity in GMO food standards across countries.

Tab. 2.1 Effect of socio-economic variables on $GMOw_{ij}$ index

	Dependent Variable GMOwij		
Variables	(1)	(2)	(3)
Trade costs			
Log distance	-2.62***	0.02	0.04
	(-10.27)	*(0.09)*	*(0.14)*
Common language	0.23	2.83***	2.82***
	(0.31)	*(4.23)*	*(4.22)*
Colonial links	-1.23	-3.31***	-3.25***
	(-0.94)	*(-4.52)*	*(-4.44)*
Log (1+tariff)$_{ij}$	-2.92	-46.31***	-45.08***
	(-1.46)	*(-9.21)*	*(-7.76)*
Institutional difference			
IPR index	-3.52***	0.15	0.15
	(-6.49)	*(0.24)*	*(0.24)*
Health expenditure	-0.38***	-0.94***	-0.94***
	(-3.21)	*(-7.95)*	*(-7.89)*
Polity 2	0.08*	0.01	0.01
	(1.78)	*(0.17)*	*(0.15)*
Economic controls			
GDP	1.14***	-0.17	-0.18
	(6.64)	*(-0.96)*	*(-0.97)*
GDPpc	-1.55***	-1.10***	-1.08***
	(-5.41)	*(-4.49)*	*(-4.23)*
Trade flows	0.78***	1.23***	1.22***
	(12.13)	*(11.85)*	*(11.81)*
EU members			0.62
			(0.79)
Constant	96.04***	66.27***	66.14***
	(41.13)	*(16.46)*	*(16.47)*
Adj. R-squared	0.16	0.62	0.62
Observations	3306	3306	3306
FE Importer and exporter	No	Yes	Yes

Notes: figures refer to OLS regression. In parenthesis t-value. ***, ** and * indicate significance level at 1%, 5% and 10% respectively.

Tab. 2.2 Effect of socio-economic variables on $GMOd_{ij}$ index

	Dependent Variable GMOdij		
Variables	(1)	(2)	(3)
Trade costs			
Log distance	-3.04***	-2.70***	-2.51***
	(-10.05)	*(-5.71)*	*(-5.35)*
Common language	-0.31	1.05	0.97
	(-0.27)	*(1.02)*	*(0.95)*
Colonial links	-2.79*	-4.46***	-3.74***
	(-1.86)	*(-3.34)*	*(-2.80)*
Log (1+tariff) $_{ij}$	-21.95***	-121.61***	-106.52***
	(-8.37)	*(-14.26)*	*(-11.21)*
Institutional difference			
IPR index	-8.61***	-2.93***	-2.91***
	(-13.70)	*(-3.39)*	*(-3.37)*
Health expenditure	-0.61***	-2.28***	-2.20***
	(-3.62)	*(-12.24)*	*(-11.93)*
Polity 2	0.02	0.25***	0.23***
	(0.32)	*(2.62)*	*(2.45)*
Economic controls			
GDP	-0.71***	0.03	0.02
	(-2.95)	*(0.09)*	*(0.06)*
GDPpc	-0.48	0.90***	1.12***
	(-1.47)	*(2.27)*	*(3.42)*
Trade flows	0.32***	0.74***	0.72***
	(4.52)	*(5.59)*	*(5.55)*
EU members			7.59***
			(5.19)
Constant	106.94***	112.32***	110.81***
	(39.75)	*(23.09)*	*(22.97)*
Adj. R-squared	0.19	0.49	0.49
Observations	3306	3306	3306
FE Importer and exporter	No	Yes	Yes

Notes: figures refer to OLS regression. In parenthesis t-value. ***, ** and * indicate significance level at 1%, 5% and 10% respectively

We developed a composite index of the 'complexity' of GMO regulations for sixty countries, as well as an 'objective' score for six GMO regulatory sub-dimensions. From the literature, the most relevant sub-dimensions composing GMO regulations appear to be approval process, risk assessment, labeling, traceability, coexistence and partnership in international agreements.

Using three different specification of OLS regressions, we investigate the determinants that lead countries to set similar GMO standards. We test the effects of several socio-economic and institutional variables on two different similarity indexes of GMO regulation.

Explanatory variables have been classified in three main groups: trade costs, institutional differences and economic characteristics. The set of variables was tested by comparison between a pooled specification, the inclusion of country fixed effects and the inclusion of country fixed effects coupled with a dummy variable controlling for EU membership.

Results show that in all three specifications and for both measures of GMO regulation, similarity in health expenditure and trade flows are two strong determinants of harmonized GMO standards. Great differences in health expenditure induce adoption of different GMO standards, suggesting that in countries with different development in health systems, regulators set different standards. Moreover, high bilateral trade of major GM crops induce countries to set similar regulations. This leads to the formation of commercial sub-agreements that reduce the protectionist impact of GMO regulation.

Tariffs are an important determinants of GMO standard harmonization. They have a negative impact on harmonization, meaning that the absence of tariffs among country pairs induce similar GMO regulations, resulting in a stronger reduction of trade protectionism.

Finally, controlling for country fixed effects and for EU membership, common language, patent right regulations and democracy, seem to play some role in determining similarity in

GMO regulations, although these effects are not robust, and appear sensitive to the way the GMO bilateral index is measured.

Chapter 3

GMO Regulations and Trade: Empirical Evidence[1]

3.1. Introduction

The stark polarization of public and private policies on genetically modified organisms (GMOs) represents one of the main issues of modern international agri-food supply chain. GMO standards differ strongly across countries and regions, resulting in a market fragmentation that currently challenges the international trading regime (Isaac et al. 2004).

Several authors have pointed out that the stringency of the GMO regulations of big agri-food importers, like the European Union (EU) and Japan, in contraposition with the 'soft' regulations of GMO producers, like the US and Argentina, could represent a serious problem for the developing country' strategy concerning GMO production and regulations (see, e.g., Tothova and Oehmke, 2004; Anderson and Jackson, 2004). Indeed, while the potential

[1] This chapter is based on Vigani et al. (2010).

gains from GMO adoption by several Asian and African countries appear particularly high (see Huang et al. 2004; Anderson, 2005; Smale et al., 2009; Gruére et al. 2009), developing countries are struggling because of the trade–off between the expected production and agronomic benefit from GM crops, and the potential loss of access to rich markets with strong consumer opposition to GMOs.

The purpose of this paper is to investigate the trade effect of GMO standards across a large sample of developing and developed countries. To deal with, the paper develops a composite index of the stringency of GMO regulations for a sample of about sixty countries, to study how similarity/dissimilarity in GMO regulations affects bilateral trade flows.

The paper adds to the existing literature in three main directions. First, we study the trade effect of GMO regulations using an 'objective' multidimensional index of GMO standard and its sub-components, to shed light on which regulatory dimensions matter the most for trade flow. Thus, we depart from the standard approach of using simple dummy variable to capture the trade effect of GMO regulation as, for example, in Disdier and Fontagnè (2008)[2]. Second, we focus on 'harmonization' issues instead of the more traditional concern about standards as a barrier to trade. This is done by using in the empirical analysis a bilateral measure of GMO standards, with the aim of capturing the level of 'harmonization' in GMO regulations. Thus, our research does not directly address the trade reduction effect induced by the stringency in GMO regulations. Indeed, we try to answer a slightly different question: how much does similarity, or dissimilarity, in GMO regulations between exporting and

[2] Obviously, this does not means that using a dummy for capturing the trade effect of GMOs is a priori less interesting, as what is the best strategy also depend by the research question and/or data availability. However, it is clear that if we want to understand which GMO regulatory dimension matter for trade flow, then one need to go behind a simple categorization based on dummy variable. Gruère et al. (2009) represent an example in that direction, however they limited the investigation to GMO labeling policies.

importing countries affect bilateral trade in GMO related products? This question appears more relevant to understand the actual pattern of a (developing) country's strategy to GMO regulations.

The final contribution of the analysis is the tentative to account for the potential bias induced by the endogeneity of GMO standards to trade flow, an issue rarely covered by existing empirical studies[3]. Indeed, both political economy motives and genuine economic reasons – namely the idea that countries set-up GMO regulations by trading-off internal benefits with external (trade) costs – call for the endogenous nature of GMO regulations to bilateral trade flows.

The paper is related to several studies on the trade-related aspects of the introduction of GMO and the costs induced by its regulations[4]. Within this literature, particularly relevant for our analysis are studies by Cadot *et al.* (2001), Parcell and Kalaitzandonakes (2004), Disdier and Fontagné (2008), Tothova and Oehmke (2004), Veyssiere (2007), and Gruére *et al.* (2009).

Cadot *et al.* (2001) discuss the 'regulatory protectionism' aspect of EU GMO regulations, reporting preliminary evidence indicating that there were no repercussions to the US export of corn seeds. However, they did find a negative effect with regard to other forms of corn, suggesting that downstream traders' and food retailers' private decisions not to purchase GM products were more important than the cultivation bans. Using a different approach,

[3] To date, in the gravity literature concerning the trade effect of non-tariff barriers (NTBs) the problem of the endogeneity of NTBs to trade flow is rarely taken into account. Exception to this rule can be found in Olper and Raimondi (2008) and Djankov et al. (2008).

[4] Important studies about trade-related aspects of genetically modified organisms (GMOs) introduction and regulations, can be found in Lapan and Moschini (2004) and Smyth *et al*. (2006). The first paper shows that labeling regulations on trade in GMOs can redistribute income among trading nations, and may benefit the importing country. Differently Smyth *et al*. (2006) show that the trade patterns of GMO products displayed changes after the introduction of GMO regulations. Concerning GMO labeling issues, see also: Runge and Jackson (2000), Fulton and Giannakas (2004) and Veyssiere and Giannakas (2004), among others. Finally, see Josling *et al*. (2005), Sheldon (2002) and Gruére (2006) about EU, US and worldwide GMO regulatory systems.

Parcell and Kalaitzandonakes (2004) did not find any effect on future prices after major food companies announced a voluntary ban on GMO crops.

More recently, Disdier and Fontagné (2008) used a gravity equation to estimate the reduction of exports from complainants to the EU de facto moratorium on GMOs for potentially affected products. In general terms, and contrary to the findings of Cadot et al (2001) and Parcell and Kalaitzandonakes (2004), they show that the EU moratorium, as well as other European GMO regulations, have negative trade effects on exporting country.

Particularly relevant to our analysis are studies of Tothova and Oehmke (2004), Veyssiere (2007) and Gruére et al. (2009). The first paper developed a Krugman-style trade model to study the endogenous choice of different countries to set GMO standards, and the consequent endogenous formation of 'clubs' of countries that acts as a sub-global preferential trading agreement. Their model suggests the formation of two trading blocs, one in favor, the other against GMOs. In between these two blocs there emerges a third group of developing countries potential losers, that face a tension coming from lower production costs (through the adoption of GM crops) and the maintenance of an export market of conventional varieties, such maintenance being achieved by restricting GMO production. A similar question is analyzed by Veyssiere (2007), who studied the dilemma facing large exporting countries of agricultural products; such countries have to determine whether or not to approve GM products with or without a labeling regime. An interesting result from their model is that GM product approval is optimal under a labeling regime, whereas non-approval is optimal in the absence of mandatory labeling requirements.

Finally, Gruére *et al.* (2009) adopt a political economy approach to evaluate the importance of socio-economic factors in the selection of GM labeling regulation. They show, theoretically and empirically, that interests related to production and trade has an important role on GM labeling regulation choices. In particular, in developing countries regional influences and trade factors may be more important than domestic consumer preferences or anti-GM campaigns. Clearly, all these evidence highlight the importance of treating GM regulations as potentially endogenous to trade flows.

The organization of the chapter is as follows: Section (3.2) explains how we constructed the GMO regulatory index; Section (3.3) presents the data and specifications of the empirical model; Section (3.4) gives the results and discusses them; while Section (3.5) conclude.

3.2 GMO regulation index

The GMO index (fully developed in Chapter 2) has been built for 60 countries, namely: the most of the European Union and OECD members; exporters of agricultural goods like Argentina, Brazil, China, India, Ukraine and other Asian countries; producers countries like Bangladesh, Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam; other countries as: Chile, Colombia, Guatemala, Israel, Jamaica, Peru, Russia, Saudi Arabia, Venezuela, Kenya, South Africa, Zambia, and Zimbabwe. Collection of data on regulation was based on two main criteria, first the economic relevance of the selected country in the agricultural international markets, second the sufficient availability of information on GMOs regulations for the selected country.

To construct the index we referred as main source of data to the GAIN reports on biotechnology of the Foreign Agricultural Service of the USDA and to official national acts and reports. The index is composed by six dimensions related to the production and the commercialization of GMOs: ‘approval process’, ‘risk assessment’, ‘labeling policies’, ‘traceability system’, ‘coexistence’ and ‘membership in international agreements GMO related’.

We scored each dimension with increasing values proportional to the increasing restrictiveness of the regulation, starting from 0 (first condition) to the highest number of conditions identified for each category (e.g. the higher score of labeling policies is 5 whereas for coexistence is 4). For those countries 'GM free' the highest score is assumed.

To obtain the overall GMO index, we sum each condition and we normalized each dimension so that dimensions vary between 0 and 1. After further normalization, we obtained the final GMO index that can take on any value between 0 and 1. Higher values indicate a more complex (hence restrictive) national GMO regulation, which require more expansive compliance costs for exporters.

Because in our analysis we assessed the effect of the overall GMO regulation on trade as well as the effect of each component of the regulation to analyze which are the requirements with greater impact, we provide a brief discussion of each regulatory dimension.

The approval procedures are the pre-conditions to any possible handling of a GM product. The approval status of a GMO concern import and cultivation separately and are related to human and environmental safety and it represent a fixed cost to market access (Gruére, 2006). We can distinguished two main approaches for approval procedures: the 'precautionary principle' followed by the EU and the 'substantial equivalence' approach of the US. Between the two there are many other approaches followed by different countries. Five level of restrictiveness of approval processes has been defined (from 0 to 4), based on the degree of domestic implementation of the regulation. We scored 0 those countries where GMO approval does not put any constrain on GMOs production or marketing and 1 if there exists a mandatory approval process but no enforcement. Conditions zero and one include developing and emerging countries which take a 'wait and see' position with respect to the international polarization led by the EU and US. A score of 2 is assigned when the mandatory approval process follows the principle of substantial equivalence and 3 when a mandatory approval process follows the precautionary principle (most EU members, Japan and fast-growing income countries like China and India are scored in the third condition). Finally, a score of 4 is assigned to GMO free countries.

Risk assessment requirements have the goal to investigate potential harmful effects of GM products and cultivations on human health and the environment, and testing and detection methods are a function of country' approach, whether based on substantial equivalent or precautionary principle. Three level of restrictive requirements has been identified: a score of 0 is referred to absence of risk assessments requirement; 1 if risk assessment is at proposal stage; 2 if the risk assessment framework is already enforced and 3 indicate GMO free countries.

Particularly important is the effect of GM labeling policies because they directly affect consumer demand. Other than provide just information on presence of GMOs in the ingredients, labels can act as a warning of potential hazards affecting the demand for GM and non-GM products (Gruère, 2006). Countries set different thresholds of content of GM ingredients to be labeled, this requirement represent a variable cost for exporters and producers. The entity of compliance cost depend on: the threshold level, the capacity of the public authority to enforce labeling requirements, and the capacity of industry to comply with labeling rules. On the basis of the labeling thresholds, five level of stringency of labeling policies has been scored. We assigned a 0 score in absence of labeling requirements; 1 with voluntary labeling regimes; 2 in the presence of a mandatory regime with a threshold equal or higher than 5%; 3 with mandatory regime but with a threshold equal or lower than 1% and, finally, 4 in GM free countries.

As well as labeling requirements, traceability represent a variable cost that can increase significantly compliance costs. Traceability consist in collect and carry information about the GM product during the whole food chain until producers, maintaining the identity preservation of the products. The aim of the traceability system is to readily identify lots containing unapproved GMOs or, more in general, containing potential harmful GM products for a rapid withdrawal from the market. Liability schemes are also required. Traceability requirement has been scored in 4 categories: 0 if the country does not require any traceability or IP system; 1 if traceability has been proposed but not yet enforced or if an IP system is required; 2 if traceability is mandatory and 3 if the country is GM free.

Differently, the purpose of coexistence is to guarantee to consumers and farmers the right to choose what to consume or produce among GM, traditional and organic products. In a coexistence regime is not possible to cultivate nearby fields of GM and organic crops or manage them in short rotations. Moreover, mechanisms to prevent pollen flows, refuges areas and dedicated machineries as well as compensation and liability systems are required. To build the index we scored 0 those countries without any coexistence rule; 1 if coexistence policies has been only proposed; 2 if the regulation consist of partial guidelines; 3 if exhaustive coexistence guidelines are adopted and 4 if the country is GM free.

Finally, within several international agreements we considered the two who has a recognized effect on the trade of GM products (or an expected trade effect once they will be totally enforced): the Codex Alimentarius and the Cartagena Protocol on Biosafety. The Codex Alimentarius has the purpose of define harmonized standards worldwide, while the Cartagena Protocol on Biosafety (BSP) introduce shared procedure of risk assessment and management and trans-boundary movements of Living Modified Organisms (LMOs). We assign three different scores: 0 if the country does not adhere to the two agreements; 1 if the country subscribe only one of the two agreements and 2 when the country subscribes both agreements.

3.3 GMO standards and international trade

3.3.1 Trade data

To study the effect of GMO standards on trade flow we have considered trade data related to three major potentially affected agricultural products: maize, soybean and rapeseed, both for human consumption and animal feed. We also include cotton products, mainly related to agri-food system. Trade data comes from the Commodity Trade database maintained by the United Nations Statistical Division (UN-COMTRADE). We work at the 6-digit level of the 2002 Harmonized System (HS) classification. Because it is not possible to distinguish between GMO and non-GMO products, we considered raw, transformed and by products, both for food and for feed recognized in the literature as potentially sensitive to transgenic crops (see USDA, 2008).

As in previous empirical analyses (see Disdier and Fontagné, 2008) we face a sort of identification problem, because a reduction in trade flows can only partially be attributed to the existence of GMO restrictions. We take care of this issue through a proper specification of the gravity equation, ruling out, as close as possible, the potential determinants of trade flow different from GMO standards, like other trade cost factors.

The four aggregates considered are called for simplicity: Maize, Soybean, Oilseed Rape, and Cotton. For cotton, we take into account headings related to the agri-food channel, particularly seeds, oils and cake that are exploited as animal fodder or as a part of such feed[5]. In the empirical analysis, we considered both an

[5] The HS 2002 (6-digits) headings used are as follow. *Maize* (corn): 071040, 100510, 100590, 110220, 110313, 110320, 110423, 110812, 151521, 151529, 190410, 190420, 200580, 230210, 230310; *Soybean*: 120100, 120810, 150710, 150790, 210310, 210610, 230400; *Rape*: 120510, 120590, 151411, 151419, 151491, 151499, 230649; *Cotton*: 120720, 151221, 151229, 230610.

overall aggregate of the four potentially GMO affected trade, and each of the four groups individually.

The country sample is selected using the following rules. Within the importing country we select all the countries for which it was possible to build the GMO regulatory index. Instead, the selection criteria for exporters is based on trade and production data from FAO source, excluding those countries that, simultaneously, have no export or production of maize, soybean, rapeseed and cotton products, respectively.

Finally, the time period considered covers the average trade flows of three years: 2005, 2006 and 2007[6]. Up to 2008, international regulations were implemented in a wide number of countries. Despite the GMO adoption start in the second half of the nineties, only in more recent years we assisted to an acceleration of the diffusion of biotech regulations. Note that, this can be attributed not only to the growing amount of biotech products traded, but also to international trade controversy which has led to the defining of GMO import and export rules.

3.3.2 A Theory-driven Gravity Equation

In this section we provide the theory at the basis of the econometric model we adopted for the empirical analysis. Our gravity equation put its roots in a monopolistic competition model in which each country export differentiated products to the others. It is assumed that firms in autarky can decide to shift from one product to the other without costs and each firm maximize its profit following by trade in different products, that is each country is completely specialized in the production of a certain product (Feenstra, 2004).

Under the gravity equation the bilateral trade between two countries is directly proportional to the product of the countries'

[6] For practical reasons, we do not extend the sample period to 2008, to eliminate the possible confounding effect due to the financial crisis export slow down.

GDP, hence countries more similar in their relative size will tend to trade more. This equation performed extremely well empirically as shown by Tinbergen (1962), but was lacking of proper theoretical foundation. In the first simple versions, the gravity equations derived under the assumption of free trade and no transport costs, so that all countries have identical prices.

Nevertheless, in presence of border effects, such as transport costs or tariffs, the assumption equalized prices across country is no longer correct, because trade patterns are more complex. To deal with this problem, is necessary to assume a specific utility function with constant elasticity of substitution (CES). The utility for the representative consumer in country j is defined as:

$$U^J = \sum_{i=1}^{C} \sum_{k=1}^{N^i} \left(c_{ijk}\right)^{(\sigma-1)/\sigma} \qquad (1.1)$$

Where c_{kij} are the exports from country i to country j of good k. Because each country is specialized in the production of a single product, the export of good k are equal to consumption of goof k in country j. Moreover, c_{kij} denote the total consumption of good k in country j. We assume also that country i=1,….,C produces N_i products.

We introduce also the so called 'iceberg' transport costs formulation (Samuelson, 1952), which permit us to simplify the triple index on consumption. Thus, all products exported by country i have the same price p_{ij} in country j which includes all transport c.i.f. (cost, insurance, freight) costs. Local prices p_i for goods produced in country i are free on board (f.o.b.) which means that they do not include any transport costs. The relationship between prices is $p^{ij} = T^{ij} pi$, where $T^{ii} = 1$ and $T^{ij} >= 1$.

If prices p^{ij} are equal across varieties, then also consumption in country j is equal over all the products k=1,….,Ni exported by country i, so that $c_{kij} = c^{ij}$. Then we can simplify the utility function as follow:

$$U^J = \sum_{i=1}^{C} N^i \left(c^{ij}\right)^{(\sigma-1)/\sigma} \qquad (1.2)$$

Where c^{ij} is total consumption of products from country i to j and σ >1 is the elasticity of substitution between domestic and foreign varieties.

The representative consumer in country j will maximize (1.2) subject to the budget constrain, as:

$$Y^j = \sum_{i=1}^{C} N^i p^{ij} c^{ij} \tag{1.3}$$

Where Y^j is the aggregate expenditure and income in country j. The demand for each product c^{ij} can be derived maximizing (1.2) subject to (1.3):

$$c^{ij} = \left(p^{ij}/P^j\right)^{-\sigma}\left(Y^j/P^j\right) \tag{1.4}$$

Where P^j is the overall price index of country j, defined as:

$$P^j = \left(\sum_{i=1}^{C} N^i \left(p^{ij}\right)^{(1-\sigma)}\right)^{1/(1-\sigma)} \tag{1.5}$$

Expressing the total value of exports of country i to j as $X^{ij} \equiv Ni\, p^{ij}\, c^{ij}$, we obtain from (1.4) and (1.5):

$$X^{ij} = N^i Y^j \left(\frac{p^{ij}}{p^j}\right)^{1-\sigma} \tag{1.6}$$

p^i and p^j are aggregate indexes that may not reflect the correct border effect composed by a quantity of costs related to money, time and currency risk in transboundary movements of goods.

Moreover, following the assumption of Anderson and van Wincoop (2003) in which transportation costs are symmetric, so that $T^{ij} = T^{ji}$, we can derive, after further manipulations, that the trade pattern between exporter i and importer j is defined as:

$$X^{ij} = \left(\frac{Y^i Y^j}{Y^w}\right)\left(\frac{T^{ij}}{P^i P^j}\right)^{1-\sigma} \qquad (1.7)$$

Where Y^w is the aggregate world expenditure and:

$$\left(P^i\right)^{1-\sigma} = \sum_j \left(\frac{T^{ij}}{P^j}\right)^{1-\sigma} \frac{Y^j}{Y^w} \qquad (1.8)$$

$$\left(P^j\right)^{1-\sigma} = \sum_i \left(\frac{T^{ij}}{P^i}\right)^{1-\sigma} \frac{Y^i}{Y^w} \qquad (1.9)$$

Relation (1.7) is remarkably simple equation and give the relation between countries' GDP and their implicit price indexes, given P^i and P^j 'indexes of multilateral resistance'. This indexes are unobservable, but they can be solved using the following trade cost function:

$$lnT^{ij} = \tau^{ij} + \rho lnd^{ij} + \varepsilon_{ij} \qquad (1.11)$$

In this function trade costs are included d^{ij} as the distance between the two countries, while τ^{ij} is any other border effect associated with selling from country i to j. ε_{ij} is a random error term. T^{ij} include all effects that cause a limitation of trade between the two countries, often referred as 'iceberg' transportation costs.

Taking logs of equation (1.7) is possible to obtain its linear form, and, by substitution of trade costs given by (1.11), we obtain:

$$lnX^{ij} = \beta_1 lnY^i + \beta_2 lnY^j + \rho(1-\sigma)lnd^{ij} + (1-\sigma)\tau^{ij} + ln\left(P^i\right)^{\sigma-1} + ln\left(P^j\right)^{\sigma-1} + (1-\sigma)\varepsilon_{ij}$$

(1.10)

The dependent variable on the left is the trade flow between countries i and j. On the right side we have the distance between countries, all other border effects $(1\text{-}\sigma)\tau^{ij}$ and the multilateral resistance term $(P^i)^{\sigma\text{-}1}$ that can be solved once transportation costs $T^{ij} = T^{ji}$ are known.

In the estimation of the gravity equation (1.10) the main problem is to take account of the unobservable multilateral resistance factors, Pi and Pj, implied by the theory (Olper and Raimondi, 2008). The literature, other than the proposal of Anderson and van Wincoop (2003) to use non-linear least squares to solve the system of equations (1.7) and (1.8), proposes two other main approaches (see Feenstra, 2002): the use of price index such as consumer price index to measure the price effects in the gravity equation, as in Baier and Bergstrand (2001) and the replacement of multilateral resistance terms with country dummies as in Hummels (2001) and Feenstra (2002).

As recently shown by Feenstra (2002), only the former and the latter two approaches lead to consistent estimates. However, the latter is more complex so the use of the fixed effects method in (1.10) is preferable due to its simplicity. An important advantage of using a fixed effects specification is to sweep out any other unobservable variables omitted in the trade costs function. Thus, we will run our key estimations using the fixed effects for source and destination countries.

3.3.3 Econometric trade model

The objective of this section is to present our strategy to assess the potential trade effect of GMO regulations. The bilateral trade equation is derived from the now standard CES monopolistic competition trade model, with increasing returns to scale and iceberg trade costs, introduced by Krugman (1980). In the empirical version of the model the bilateral trade flow from j to i (Mij) can be summarized by the following log-linear bilateral trade equation:

$$LogM_{ij} = \beta_0 + \lambda_j + \chi_i + \beta_1 LogD_{ij} + \beta_2 Log\tau_{ij} + \sum_n \alpha_n Z_{ij}^n + \varepsilon_{ij}$$
(1.12)

with λj and χi the exporter and importer fixed effects to control for the size terms as well as the unobserved number of varieties (firms) and the price term of the exporter, and for the expenditure and the unobserved price term of the importer, respectively. D_{ij} is the transport costs proxy by distance between i and j, τ_{ij} is the ad valorem bilateral tariff, Z_{ij} any other bilateral trade costs different from distance and tariffs and, finally, ε_{ij} is an error term. The parameters β_1, β_2, and α_n are the coefficients to be estimated.

We augment this basic trade equation through the introduction of the GMO regulatory index in the vector of other trade costs, Z_{ij}. Due to the cross-sectional nature of our dataset, we work with a GMO index on a bilateral basis. More specifically, we computed two different GMO bilateral indices.

Our preferred index has been already defined in section 2.3 and is the $GMOw_{ij}$, based on the similarity index of Anderson (2009).

However, given our purpose of studying also which regulatory dimensions matter the most for trade flows, use was made of a second bilateral index called GMO_{ij}. This second index is similar to the previously defined GMOd_{ij} and is simply obtained by the absolute deviation of our GMO index across country pairs, computation is as follow: $GMO_{ij} = |GMO_i - GMO_j|$. This is also computable for each regulatory dimension taken individually. Thus the GMO_{ij} bilateral index increases in the level of dissimilarity or distance in GMO regulations across country pairs or, put differently, it represents an inverse index of 'harmonization' in GMO regulations. Finally, note that, given the definition of our bilateral indices they should display opposite sign coefficients in the regression results as $GMOw_{ij}$ is a similarity index, while GMO_{ij} is a dissimilarity index. Indeed, the correlation coefficient between them is negative and equal to -0.60.

Data on distance, with dummies for other trade costs normally used in similar exercises (contiguity, language, and colony), are taken from CEPII (Centre d'Etude Prospectives et d'Informations Internationales). Finally, bilateral tariffs are obtained from the MAcMap database jointly developed by ITC (UNCTAD and WTO, Geneva) and CEPII (Paris). It includes ad-valorem, as well as specific components of each bilateral tariff line at the six digit level of the Harmonized System. Note that the inclusion of bilateral tariffs in the trade costs function is particularly important in our context to proper identify the effect of GMO regulations. Indeed, if our bilateral GMO index is positively correlated with bilateral tariffs, then omitting tariffs from the gravity equation results in an overestimation of the GMOs effect on trade flow[7].

Finally, with concern to the estimation method, when equation (1) is applied at the disaggregated trade level, the first problem that emerges is the presence of a high number of zero bilateral trade flows. One of the most common methods of dealing with zero trade is the Heckman (1979) two stage selection correction: i) a Probit equation where all the trade flow determinants are regressed on the indicator variable, T_{ij}, equal to 1 when j exports to i and 0 when it does not; ii) an OLS second-stage with the same regressors as the Probit equation, plus the inverse Mills ratio from the first stage, correcting the biases generated by the sample selection problems[8]. Following the modification suggested by Helpman et al. (2008) and supported by Martin and Pham (2008),

[7] The correlation between tariffs and NTBs is an empirical question. To date, broad evidence of a positive correlation for agri-food products can be found in Kee et al (2008). In our sample, running a fixed effect regression of tariffs on the GMO index, the coefficients of tariffs is positive and strongly significant.

[8] As an alternative approach to deal with zero trade flows and heteroskedasticity problems, Santos Silva and Tenreyro (2006) recommended the Poisson Pseudo Maximum-Likelihood (PPML) estimator. However, Martin and Pham (2008) and Raimondi and Olper (2009) have shown that the PPML approach produces biased results when used in the presence of a large fraction of zero trade flow, a situation consistent with recent trade models with firms' heterogeneity (Melitz, 2003; Helpman *et al.* 2008) and very frequently working at a disaggregated product level as in our application.

we omitted in the second OLS stage an independent variable associated with the fixed trade costs of establishing trade flow[9].

3.4 Results

In this section the results of the econometric estimation of equation (1.12) are reported and discussed. First we focus the attention on results based on the assumption that the GMO index is an exogenous variable. Then with check for robustness of the results by considering the potential endogeneity issues. We follow this strategy for both comparability and practical reasons. Indeed, almost all previous papers have considered GMO regulations as an exogenous variable. Moreover, it is well know that instrumenting such variable it is a quite difficult task in a gravity environment (more on this below).

Table 2 reports the regression results of equation (1), pooling the data across the four groups of products and testing for the trade effect of the 'aggregated' GMO indices (Column 1 and 2) and their sub-components (Columns 3-9). Figures refer to the second stage of the Heckman procedure. The Mills ratio reported at the bottom of the table, is strongly significant in every regressions, giving a statistical justification to the use of the Heckman procedure to correct for selection bias. This is not surprising given the large fraction of zero trade flows of the dataset.

Starting from standard gravity covariates, the distance coefficient is always negative and significant, while the common border and colony dummies are positive and significant. As expected, bilateral tariffs have a negative and significant effect on bilateral trade flows. If we give a structural interpretation to the tariff coefficients, equal to $(1 - \sigma)$ with $\sigma > 1$ the elasticity of substitution between home and foreign products, then we have an estimate of such elasticity. Its average value, around 3, is broadly

[9] The underlying idea is that fixed trade costs, here proxy by the language dummy, especially affect the probability to export. Thus it is included only in the (first stage) selection equation, but not in the level OLS equation (see Martin and Pham, 2008).

in the same order of magnitude of recent estimate reported by Raimondi and Olper (2009).

Table 3.1 GMO regulations and trade: Regression results.

	Dependent variable Ln (X_{ij})								
Variables	$GMOw_{ij}$	GMOij	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GMO Index	1.93***	-1.53***							
	(0.35)	*(0.19)*							
Labeling			-0.80***						-0.54***
			(0.13)						*(0.14)*
Approval				-0.76***					-0.36**
				(0.16)					*(0.17)*
Traceability					-0.52***				-0.29***
					(0.10)				*(0.11)*
Risk						-0.50			-0.02
						(0.49)			*(0.49)*
Coexistence							-0.31***		-0.14
							(0.08)		*(0.09)*
Agreements								-0.21*	-0.05
								(0.12)	*(0.12)*
Ln Distance $_{ij}$	-1.73***	-1.65***	-1.71***	-1.75***	-1.68***	-1.77***	-1.75***	-1.76***	-1.65***
	(0.06)	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*	*(0.06)*
Contiguity	*1.27****	1.30***	1.30***	1.27***	1.29***	1.26***	1.26***	1.26***	1.31***
	(0.09)	*(0.09)*	*(0.09)*	*(0.09)*	*(0.09)*	*(0.09)*	*(0.09)*	*(0.09)*	*(0.09)*
Colony	*0.30****	0.36***	0.32***	0.30***	0.34***	0.25**	0.25**	0.27***	0.37***
	(0.10)	*(0.10)*	*(0.10)*	*(0.10)*	*(0.10)*	*(0.10)*	*(0.10)*	*(0.10)*	*(0.10)*
Ln (1 + tariff $_{ij}$)	*-1.95****	-1.88***	-1.97***	-2.01***	-1.88***	-2.02***	-1.99***	-2.02***	-1.88***
	(0.20)	*(0.20)*	*(0.20)*	*(0.20)*	*(0.20)*	*(0.20)*	*(0.20)*	*(0.20)*	*(0.20)*
Mills ratio	*2.20****	2.19***	2.19***	2.20***	2.17***	2.18***	2.19***	2.18***	2.18***
	(0.14)	*(0.14)*	*(0.14)*	*(0.14)*	*(0.14)*	*(0.14)*	*(0.14)*	*(0.14)*	*(0.14)*
Constant	5.95***	10.40***	7.75***	7.99***	7.25***	7.87***	7.73***	7.84***	7.39***
	(0.67)	*(0.79)*	*(0.57)*	*(0.56)*	*(0.58)*	*(0.57)*	*(0.58)*	*(0.57)*	*(0.58)*
Observations	17112	17112	17112	17112	17112	17112	17112	17112	17112
FE Importer, exporter and	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: figures refer to the II stage of the Heckman regression. In parentheses robust standard error. ***, ** and * indicate significance level at the 1%, 5% and 10%, respectively. Each regression include country fixed effects for importer and exporter, and HS 2-digit products.

Turning to the variable of interests, column (1) shows that the $GMOw_{ij}$ has a positive and strongly significant coefficient (p-value < 0.01). Because the index measures the across-countries closeness in GMO regulations, a positive coefficient means that bilateral trade flow is increasing in the similarity of GMO regulations. The magnitude of estimated coefficient implies that a one standard deviation increase in GMO regulatory distance, equal to 0.148 points, increases exports by about 30 percent, all else remaining equal. To give sense to this number, note that it approximately corresponds to a change in $GMOw_{ij}$ index from the value of France-Philippine (= 0.76) to that of France-Poland (= 0.92). Thus the effect it is not only statistically significant but appears also relevant from an economic point of view.

Column (2) reports results using our alternative GMO_{ij} index based on the absolute regulatory difference. The results are very similar, the only difference being the negative sign of the estimated coefficient as now we are measuring dissimilarity in GMO regulations. Columns from (3) to (9) investigate which GMO regulatory sub-components matter the most. In line with the results of column (2), all GMO components exert a negative effect on bilateral trade flow, and most of them are statistically significant at 5% level, with the exception of international agreements that is only barely significant, and the risk assessment component that is not significant. However, as the different regulatory components tend to be positive correlated with each other, to better disentangle their differentiated effect, in Column (9) we run a specification that consider them simultaneously. Not surprising, their estimated coefficient decrease somewhat in absolute magnitude. Interesting, the (theoretically) most important dimensions, namely labeling, the approval process, and traceability, remain strongly significant at 1% level. Because each component is normalized to vary from 0 to 1, the results suggest also that differences in Labeling policies are the GMO regulatory dimension most detrimental to trade, followed by the approval process and traceability requirements. This finding is in line with the notion that GMO labeling' provisions is a complex field of across countries conflict in terms of trade policies (Carrau, 2009). Thus as long as an agreements will not internationally shared, for example through the Codex Alimentarius, labeling is going to remain one of the major regulatory components that have effects, either directly (e.g. food marketing) or indirectly influencing consumers choice and information.

Table 3.2 GMO regulations and trade: Regressions at product group level.

	Dependent variable Ln (X_{ij})				
Variables	**Total**	**Corn**	**Soybean**	**Rape**	**Cotton**
GMO Index	1.93***	2.05***	3.27***	2.02	3.92
	(0.35)	*(0.46)*	*(0.74)*	*(1.23)*	*(3.07)*
Ln Distance $_{ij}$	-1.73***	-1.83***	-1.47***	-2.22***	-3.94***
	(0.06)	*(0.09)*	*(0.13)*	*(0.25)*	*(1.18)*
Contiguity	1.27***	1.09***	1.36***	1.58***	1.48
	(0.09)	*(0.11)*	*(0.19)*	*(0.23)*	*(0.93)*
Colony	0.30***	0.18	0.02	0.30	-0.23
	(0.10)	*(0.14)*	*(0.23)*	*(0.26)*	*(0.77)*
Ln (1 + tariff $_{ij}$)	-1.95***	-1.28***	-2.06***	-3.68**	2.86
	(0.20)	*(0.24)*	*(0.63)*	*(1.51)*	*(2.40)*
Mills ratio	2.20***	2.00***	1.70***	2.41***	5.30***
	(0.14)	*(0.19)*	*(0.29)*	*(0.46)*	*(1.87)*
Constant	5.95***	6.31***	2.18	6.73***	7.79*
	(0.67)	*(0.93)*	*(2.13)*	*(2.00)*	*(4.19)*
Observations	17112	8236	3983	2119	316
FE Importer, exporter and HS2	Yes	Yes	Yes	Yes	Yes

Notes: figures refer to the II stage of the Heckman regression. In parentheses robust standard error. ***, ** and * indicate significance level at the 1%, 5% and 10%, respectively. Each regression include country fixed effects for importer and exporter, and HS 2-digit products.

Table 3.2 investigates the sensitivity of different product groups to the $GMOw_{ij}$ regulatory index, by running regressions for each group separately. Column (1) replicates the pooled regression results from Table 2 (column (1)), for comparison purposes. The estimated coefficients on the $GMOw_{ij}$ is positive for all the product groups considered but statistically significant only for corn and soybean, suggesting that these agricultural commodities are the more affected by GMO regulations. Differently, we do not detect significant effect for either rape or cotton trade flows. While for cotton the results make sense as it is only partially involved in the agri-food chain, more surprising are the results for rape, as there is evidence that segregating non-GMO from GMO rapeseed is much more complicated than segregating non-GMO corn or soybean. However, note that when use is made of GMO_{ij} index instead of $GMOw_{ij}$, also the coefficient for rape turn out to be significant (results not shown).

3.4.1. Is GMO regulations endogenous to trade flows?

There are different potential sources of endogeneity bias in our model. However, here we are especially concerned with endogeneity due to potential simultaneity bias between GMO regulations and bilateral trade flow. In fact, a large political economy literature on trade policy suggests that not only does trade policy affect imports, but also that trade policy itself is affected by the level of imports (see Trefler, 1993; Grossman and Helpman, 1994). In such a case, if import and protection are not modeled as being simultaneously determined, then the estimated impact of protection on imports will be biased downward.

The applicability of this reasoning to our specific context is not so clear, however, as standards regulation in general, and GM regulations in particular, *prima facie*, are not trade policy. However, in our specific context we have important reasons to suspect that GMO regulations could be affected by trade flow. Indeed, as discussed in the introduction, previous evidence and conceptual model stresses that in recent years many developing countries have set GMO standards taking care of the trade-off between agronomic advantage and market access loss in countries with GMO consumer concerns (see Tothova and Oehmke, 2004; Veyssiere, 2007; Gruére *et al.*, 2009).

Generally speaking, it is difficult to address this simultaneity bias because of the lack of good instruments, as almost all the potential determinants of GMO regulations exert also an effect on bilateral trade flows, thus they tend to be weak instruments (see Baier and Bergstrand, 2007). Previous tentative to deal with this kind of endogeneity in gravity models have followed the idea of Lee and Swagel (1997), using industrial conditions as instruments for trade policy (see, e.g., Olper and Raimondi, 2008). However, working at the HS 6-digit level it is impossible to adopt this strategy due to data constraints. An alternative strategy followed in this paper is that propose by Djankov *et al.* (2010), who deal with the potential endogeneity of trade times in gravity model by using the trade times of neighboring countries. The intuition is that while trade flows may affect domestic trade times, they are less likely to affect transit times abroad. Following a similar logic we instrument the GMO index by using the weighted average GMO index of the five closest neighbors, using the distance between capital as a weight.

The results of this exercise are reported in Table 4. Columns (1) and (2) report a benchmark OLS and a standard IV regression, respectively. We start from these regressions because, as it is well know (see Wooldridge 2002; Persson and Tabellini, 2003), instrumental variable is also an approach to dealing with selection bias problems. Interestingly, on passing from OLS to IV regression, the coefficient of the $GMOw_{ij}$ increases by a factor five (from 1.65 to 9.61), and moreover remain strongly significant. This result gives some credence to the idea that endogeneity matters for the final results. Columns 3 and 4 give a substantial confirmation to this hypothesis. Indeed, by running a IV second stage Heckman regression, the coefficient of the $GMOw_{ij}$ index increases by about four times and, as expected, it is now virtually the same as that obtained without using the Heckman selection correction[10].

Table 3.3 GMO regulations and trade: IV regressions.

Variables	OLS	IV	*Heckman procedure* II stage OLS	II stage IV
GMOwij	1.65***	9.61***	1.93***	8.38***
	(0.36)	*(3.13)*	*(0.35)*	*(2.98)*
Ln Distance $_{ij}$	-0.85***	-0.68***	-1.73***	-1.63***
	(0.03)	*(0.08)*	*(0.06)*	*(0.08)*
Contiguity	0.96***	1.05***	1.27***	1.33***
	(0.09)	*(0.10)*	*(0.09)*	*(0.09)*
Language	0.11	-0.10		
	(0.08)	*(0.11)*		
Colony	-0.15	0.11	0.30***	0.48***
	(0.10)	*(0.14)*	*(0.10)*	*(0.13)*
Ln (1 + tariff $_{ij}$ *)*	-1.61***	-1.28***	-1.95***	-1.71***
	(0.20)	*(0.24)*	*(0.20)*	*(0.23)*
Mills ratio			2.20***	2.32***
			(0.14)	*(0.15)*
Constant	4.64***	-1.26	5.95***	-0.47
	(0.70)	*(2.59)*	*(0.67)*	*(3.03)*
Observations	17112	17112	17112	17112
FE Importer, exporter and HS2	Yes	Yes	Yes	Yes

Notes: In IV regressions the $GMOw_{ij}$ index is instrumented with the weighted average index of the five more close neighbors. In parentheses robust standard error. ***, ** and * indicate significance level at the 1%, 5% and 10%, respectively. Each regression include country fixed effects for importer and exporter, and HS 2-digit products.

[10] See Wooldrige (2002) and Bair and Bergstrand (2007) for a similar estimators. Basically it represent a three steps estimator. The first stage is the estimation of the predicted probabilities of trade, through a probit equation. The second stage is a linear regressions of $GMOw_{ij}$ on a constant, the Mills ratio from the first stage, all the covariates of the first stage plus the instruments. The first stage is estimation of the gravity equation substituting the predicted values from the second-stage regression for $GMOw_{ij}$.

Keeping in mind the usual caveats about instruments, these results appear interesting, first because they support the idea that GMO regulations is endogenous to trade flows, and secondly because they suggest that selection bias concerns seem dominated by simultaneity issues. Indeed, based on our estimate, the downward bias due to simultaneity issues is several times more relevant than that due to selection bias. To see this, it is sufficient to compare the GMO index coefficients in Table 4. Indeed, sample selection induced a downward bias in the GMO index of about 17% = ((1.93-1.65)/1.65)*100. Differently simultaneity bias induces a downward estimation of the GMO coefficient of about 334% = ((8.38-1.93)/1.93)*100.

3.5 Summary and conclusions

Motivated by the complex pattern and evolution of GMO regulations in the last decade, this paper deals with the quantification of GMO regulations on bilateral trade flows at global level. A composite index of the 'complexity' of such regulations for sixty countries, as well as an 'objective' score for six GMO regulatory sub-dimensions, has been developed. In a second step, using an econometric trade model, we have shown how bilateral similarity/dissimilarity in GMO regulations, affects trade flows for the composite index and its components. The empirical evidence highlights three main results.

First, countries with strong differences in GMO regulations trade significantly less, suggesting that what matters for trade flows are not only the stringency of the standards, but also the level of harmonization between countries. Second, the regulatory dimension that matters the most is that related to the labeling system, followed by the approval process and traceability requirements. Not surprisingly, other GM regulatory dimensions like coexistence appears less important from the point of view of trade flows, as it is more related to agriculture production stage rather than to marketing and trade issues. Third, we highlight and test the endogeneity nature of GMO regulations to trade flows, showing that simultaneity bias is potentially important. Accounting for endogeneity, the GMO coefficients increase of about 4 times, and this effect largely dominates in magnitude the traditional selection bias issues in disaggregated gravity model due to zero trade flows.

The main policy implication of this study is that a process of harmonized international standardization, could have a positive trade effect, and that is especially true with regard the labeling policies. The GMO index developed in this study shows that there are 'clubs' of countries that shares similar GM regulations, a result in line with the Tothova and Ohemke's (2004) theoretical prediction.

Chapter 4

Economic and Polity of Private Standards: Theory and Evidence for GMOs[11]

4.1. Introduction

It is well documented that private standards, introduced by private companies, are increasingly important (Henson and Hooker, 2001; Henson, 2004; Fulponi, 2007). Retailers and producers have the possibility of introducing private standards in the same domains as in which the government imposes public standards, such as safety, quality, and social and environmental aspects of production and retailing.

There are a variety of motives for companies to implement private standards. First, private standards may reduce consumers' uncertainty about product characteristics such as safety, quality,

[11] This chapter is based on Vandemoortele and Vigani (2010).

and social and environmental aspects, thus increasing consumer demand. For example, Arora and Gangopadhyay (1995) and Kirchhoff (2000) show that firms may voluntarily reduce pollution to attract 'green' consumers. Similarly, in a business to business environment, private standards allow to ensure and communicate product attributes about production, quality etc. which may facilitate firms to gear their activities to one another. This motive for private standards is especially important in an institutional environment where public standards are lacking due to government failure (e.g. enforcement problems). Gruère and Sengupta (2009) document how (foreign) private GM standards affect biosafety policies in developing countries. They argue that the dominant market power of foreign retailers, combined with the belief that private standards dictate the rules for access to developed countries' markets and that segregation is infeasible due to prohibitive costs, leads developing countries' governments to make irrational policy choices.

Second, firms may also use private standards as a strategic tool to create market segmentation by differentiating their products and softening competition. A basic result in the vertical differentiation literature is that firms can reduce price competition by differentiating the (vertical) quality attribute of their products as to increase their profits (see e.g. Spence, 1976; Mussa and Rosen, 1978; Tirole, 1988). Such quality differences can be signaled with a private standard. Several other authors have shown that in a vertically differentiated market a minimum quality standard imposed by the government (a public standard) may raise welfare, depending on the type of competition between producers (see e.g. Leland, 1979; Ronnen, 1991; Boom, 1995; Crampes and Hollander, 1995; Valletti, 1995). If the minimum quality standard is not prohibitively high such that it does not exceed the highest quality voluntarily supplied by producers, firms differentiate their quality levels such that some produce at the minimum quality level, and some at a higher quality level.

Third, private standards may also serve to preempt government regulations. For example, Lutz *et al.* (2000) show – in a vertical differentiation model with minimum quality standards – that high-quality firms may have an incentive to commit to a quality level before public standards are set, in order to induce the regulator to weaken public standards. They demonstrate that this results in welfare losses[12]. In the same line of thought, McCluskey and Winfree (2009) argue that an important advantage of private standards over public standards is that the former are more flexible in response to changes in consumer tastes and preferences, and to changes in technology. Thus, by anticipating the standard-setting of governments in setting their own private standards firms may minimize the negative effect of standards on revenues. From a political economy perspective, Maxwell *et al.* (2000) argue that firms may strategically preempt costly political action through voluntary private standards. In their model, a private standard raises consumers' welfare in the event that no public standard is imposed, and thus reduces consumers' incentives to lobby in favor of a public standard. The authors show that this preempting private standard is more stringent than the public standard which would have been imposed in the absence of the private standard.

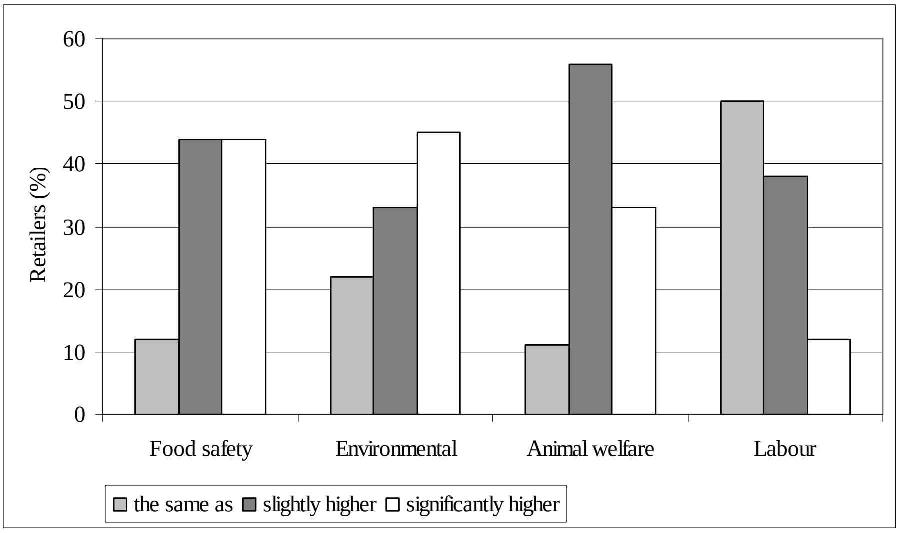
Finally, some authors argue that instead of introducing private standards, firms may simply favor the imposition of a public standard. Salop and Scheffman (1983) develop a model to show that a firm may demand stricter public standards if compliance is relatively more costly for its rivals. Similarly, Swinnen and Vandemoortele (2008; 2009a; 2009b) show that domestic producers may lobby in favor of a public standard if the standard's marginal impact on production costs is larger for foreign than domestic producers. They show that if the political power of domestic producers is sufficiently large, standards may serve as protectionist instruments, either by over- or under-standardization. Maloney and McCormick (1982) argue that firms

[12] Lutz *et al.* (2000) assume that firms are the first movers in the standard-setting process by committing to a fixed quality level, whereas other papers on minimum quality standards (such as Leland, 1979; Ronnen, 1991; Valletti, 2000; Boom ,1995) typically assume the government to be the first mover in setting minimum quality standards.

may benefit from public standards if the regulation increases marginal costs more than average costs. Their result holds either when entry is restricted, or when entry is free but the price effect exceeds the cost effect only for a subset of firms.

Importantly, empirical evidence shows that 80% to 90% of retailers assess their own private standards slightly or significantly higher than public standards (See Figure 4.1). So far, to the best of our knowledge, only the vertical product differentiation literature on minimum quality standards and Maxwell *et al.* (2000) may offer an explanation for this observation, i.e. why retailers set their private standards at higher levels than what is required by law.

Figure 4.1: Retailers' self-assessed standards compared to those of government



Source: Fulponi, 2007

The explanation proffered by the vertical differentiation literature is that those retailers who set their private standards at higher levels wish to differentiate themselves from other retailers that sell at the minimum quality standard, thus raising profits by reducing competition. However, this does not explain the high percentage of retailers assessing their own private standards as more stringent, and it neither explains the phenomenon that some private standards introduced by organizations such as GLOBALGAP (Global Good Agricultural Practices) or BRC (British Retail Consortium) are adopted by almost all retailers in European countries, thus becoming de facto public standards for retailers in these countries.

According to the political economy explanation of Maxwell *et al.* (2000), private standards may preempt public standards if the political costs of organizing consumers are sufficiently high. This model explains however only why in some domains public standards may be lacking while private standards are imposed – it does not explain why private standards may be higher in areas where public standards already exist[13].

This paper adds to this literature by offering an additional explanation for the observed relationship between the level of retailers' private standards and the governments' public standards. The argument is related to Maxwell *et al.* (2000) since the perspective taken in this paper is also a political economy one. However, so far the literature has been concerned with producers' private standards only, without taking market structure – and more specifically retailers – into account.

We argue in this paper that a retailer is willing to set its private standard at a higher level than the public standard if consumers value the quality attributes assured by the private standard and if the retailer has sufficient market power to pass the standards' implementation costs on to the producers. Unlike the private standard, the public standard is assumed to be determined in a political game where producers, retailers, and consumers have some political power to influence the standard-setting process. Since producers bear (most of) the implementation costs, they contribute in favor of a lower public standard. Because of their political power, the resulting public standard is set at a lower level than the private one, which is the level preferred by

[13] In the explanation of McCluskey and Winfree (2009), public standards are imposed (even though preempted by private standards) but at equal or higher levels than private standards.

the retailer. Hence our model combines both aspects of retailers' market power and producers' political power to explain why private retailers' standards may be set at higher levels than public standards.

An additional contribution is that, in line with Gruère and Sengupta (2009), we document retailers' GM standards and compare these with their public counterparts. We provide data on private GM standards set by 45 global food retailers which allows us to empirically assess the difference between private and public GM standards.

The paper is structured as follows. First we specify the different agents in our model, i.e. consumers, producers, the retailer, and show how a standard affects them. We also derive the market equilibrium. Second, we analyze the level of the government's public standard when the latter is determined in a political economy game where producers and the retailer contribute to the government to influence the public standard-setting process. We model this political economy game along the lines of Swinnen and Vandemoortele (2009b), which is based on the seminal model of Grossman and Helpman (1994). Third, we determine the retailer's optimal private standard in an environment where the retailer has market power to impose a private standard that involves implementation costs for producers but reduces informational asymmetries which is valued by consumers. We compare this level of the retailer's optimal private standard with the politically optimal public standard and show under which conditions the public standard is set at lower levels than the private one. We assume that the public standard is set first, independent from the private standards' level[14]. We limit ourselves to a closed-economy model to refrain from barriers-to-trade issues. Fourth, we provide an empirical application by presenting data on private GM standards for a large number of

[14] If the retailer takes into account that its private standards will be higher than the public one, independent of whether they lobby or not, it is optimal for them to refrain from lobbying which is a costly activity. The absence of lobbying by the retailer would lower the public standard even further which strengthens our argument.

global retailers, document differences between retailers' strategies in various markets. The last section concludes.

4.2 The model

A key issue is obviously how to model standards. The approaches in the literature differ importantly. Some (such as Bockstael, 1984; Ronnen, 1991; Valletti, 2000) assume that consumers can costlessly observe product characteristics ex ante, while others (such as Leland, 1979) assume that consumers are ex ante uncertain about the characteristics of the product. In the latter case standards can improve upon the unregulated market equilibrium by reducing the asymmetric information between consumers and producers. Yet other studies (such as Copeland and Taylor, 1995; Fischer and Serra, 2000; Anderson *et al.*, 2004; Tian, 2003; Besley and Ghatak, 2007) model the effect of standards as their impact on consumption externalities. This could relate to, for example, minimum standards on catalytic converters in cars or GM foods. Most studies consider that the introduction of standards implies compliance costs for producers (amongst many others Leland, 1979; Ronnen, 1991; Valletti, 2000). In this paper we follow the approach of Swinnen and Vandemoortele (2009b). We extend their model to include a third party, a retailer, which exercises its market power.

4.2.1 Consumers

Consider therefore a closed economy where consumers have heterogeneous preferences for a standard[15] imposed in this sector. A standard which guarantees certain quality/safety features of the

[15] The standards under analysis have a direct effect on the utility of consumers. Hence these standards are 'quality standards' (see Fischer and Serra, 2000) but for simplicity we refer to them as 'standards'.

product affects utility as it reduces or solves informational asymmetries. Therefore a standard will induce to consume more of the product through an increased willingness to pay, ceteris paribus. For example consumers who perceive health problems with certain (potential) ingredients or production processes may increase consumption if they are guaranteed the absence of these elements. We call this the 'consumption effect'. To model this[16], assume that individuals consume at most one unit of the good and their preferences are described by the following utility function (see Tirole, 1988):

$$u_i = \begin{cases} \phi_i s - p^c & \text{if he buys the good with standard } s \text{ at consumer price } p^c; \\ 0 & \text{if he does not buy;} \end{cases} \tag{4.1}$$

where Φ_i is the preference parameter. Consumers with higher Φ_i are more willing to pay for a product with a standard s. A higher s refers to a more stringent standard. Φ_i is uniformly distributed over the interval $[\Phi\text{-}1, \Phi]$ with $\Phi>=1$ and the number of consumers normalized to 1. Consumers with $\Phi_i<p^c/s$ will not consume this product which implies that the market will be 'uncovered'. The aggregate demand function[17] is

$$D\left(p^c, s\right) = \phi - p^c/s \tag{4.2}$$

and aggregate consumer surplus equals

$$\Pi^c\left(s\right) = \int_{p^c/s}^{\phi} u_i \mathrm{d}\phi_i = \frac{s}{2}\left(\phi - \frac{p^c}{s}\right)^2 \tag{4.3}$$

[16] Our approach of modelling standards is consistent with the standard approach in the literature on minimum quality standards (see e.g. Ronnen, 1991, Jeanneret and Verdier, 1996, Valletti, 2000).

[17] For the remainder of this analysis we assume that $\Phi >= p^c/s$ such that aggregate demand is always positive.

4.2.2 Producers

On the production side, we assume that production is a function of a sector-specific input factor that is available in inelastic supply. Producers are price-takers and all profits made in the sector accrue to the specific factor owners. The unit cost function

$$G(q,s) = k \cdot q + \frac{1}{2} c \cdot s^2 \tag{4.4}$$

is increasing in the output produced *(q)* and convex in the level of standards in that sector *(s)*, with parameters k, $c > 0$.[18] [19]
We assume that a standard imposes some production constraints or obligations which increase production costs. The idea behind this assumption is that all standards can be defined as the prohibition to use a cheaper technology. Examples are the prohibition of an existing technology (e.g. child labor) or of a technology that has not yet been used but that could potentially lower costs (e.g. GM technology). Also traceability standards can be interpreted as a prohibition of cheaper production systems which do not allow tracing the production.

Producer profits are hence equal to

$$\Pi^p(s) = \max_q \left\{ q \cdot \left(p^p - G(q,s) \right) \right\} \tag{4.5}$$

where p^p is the producer price. Taking the first derivative of (4.5) with respect to output and putting the expression to zero results in the following supply function

$$q\left(p^p, s\right) = \left(2p^p - cs^2\right) / 4k \tag{4.6}$$

[18] Generalizing this specific cost function is subject of future research, and will determine to which extent our assumptions on the cost function drive our results.
[19] Modelling the cost of standards with a unit cost function that is increasing in the standard is consistent with e.g. Fischer and Serra (2000) and Tian (2003).

4.2.3. The retailer

In the sector under consideration, there is an intermediary agent that transfers the products from producers to consumers. We assume that this retailer is a monopolist who has all market power, not only in retailing but also vis-à-vis the producers and consumers. Therefore, the retailer is assumed to be a Stackelberg leader who moves first by setting consumer and producer prices to maximize its profits. Producers are price takers, maximizing their profits by setting their output quantity, and consumers maximize their individual utility by consuming the product or not. We normalize the handling costs of the retailer to zero20. Formally, the retailer thus maximizes

$$\Pi_r(s) = \max_{p^c, p^p} \left\{ \left(p^c - p^p \right) \cdot q \right\} \tag{4.7}$$

conditional on the fact that in equilibrium, for a given standard s, the producers' output has to equal aggregate demand, i.e.

$$q\left(p^p, s\right) = D\left(p^c, s\right) \tag{4.8}$$

4.2.4 The market equilibrium

Inserting Equations (4.2), (4.6) and (4.8) into the maximization of expression (4.7), we find that in equilibrium, for a given standard s,

$$p^{p*}(s) = ks \frac{\left(\phi - cs/2\right)}{\left(s + 2k\right)} + \frac{cs^2}{2} \tag{4.9}$$

[20] Future research will relax this assumption.

$$p^{c*}(s) = s\left[\phi - \frac{s}{2}\frac{(\phi - cs/2)}{(s+2k)}\right] \tag{4.10}$$

$$q^{*}(s) = D^{*}(s) = \frac{s}{2}\frac{(\phi - cs/2)}{(s+2k)} \tag{4.11}$$

where the asterisk signs denote equilibrium values. The reduced form expressions for aggregate consumer welfare, producer profits, and the retailer's profits are respectively

$$\Pi^{c}(s) = \frac{s^{3}}{8}\left(\frac{(\phi - cs/2)}{(s+2k)}\right)^{2} \tag{4.12}$$

$$\Pi^{p}(s) = \frac{s^{2}k}{4}\left(\frac{(\phi - cs/2)}{(s+2k)}\right)^{2} \tag{4.13}$$

$$\Pi^{r}(s) = \frac{s^{2}}{4}\frac{(\phi - cs/2)^{2}}{(s+2k)} \tag{4.14}$$

Total social welfare is defined as the sum of consumer surplus, and the retailer's and producers' profits, i.e.

$$W(s) = \Pi^{c}(s) + \Pi^{r}(s) + \Pi^{p}(s) \tag{4.15}$$

4.3 The politically optimal public standard

Consider a government that maximizes its own objective function which, following the approach of Grossman and Helpman (1994), consists of a weighted sum of contributions from lobbies and social welfare. Similar to Grossman and Helpman (1994), we restrict the set of policies available to politicians and only allow them to implement a public standard s (see Swinnen and Vandemoortele 2008, 2009a, 2009b for a similar approach). We assume that the producers and retailer in this sector are politically organized and that they lobby simultaneously.

The 'truthful[21]' contribution scheme of the producers is equal to the function

$$C^p(s) = \max\left\{0; \Pi^p(s) - b^p\right\} \tag{4.16}$$

in which the constant b^p represents the share of profits the producers do not want to invest in lobbying the government. One could also interpret this constant b^p as a minimum threshold, a level of profits or surplus below which the producers believe the return from lobbying is less than its cost. Similarly, the 'truthful' contribution scheme of the retailer is of the form

$$C^r(s) = \max\left\{0; \Pi^r(s) - b^r\right\} \tag{4.17}$$

with $\prod^r(s)$ the retailer's profits as defined earlier. The constant b^r can be interpreted in the same way as in the contribution schedule of the producers. The government's objective function is a weighted sum of the contributions of producers (weighted by αp), the contributions of the retailer (weighted by α^r) and the overall social welfare, where α^j ($j = p,r$) represents the relative lobbying strength:

[21] The common-agency literature (e.g. Bernheim and Whinston, 1986) states that a truthful contribution schedule reflects the true preferences of the interest group. This implies in our political economy model that lobby groups will set their lobbying contributions in accordance with their expected profits and how these are marginally affected by the standard. We refer to Swinnen and Vandemoortele (2009b) for a proof of the truthfulness of the contribution schemes in this model.

$$V(s) = \alpha^p C^p(s) + \alpha^r C^r(s) + W(s) \qquad (4.18)$$

The government chooses the level of the standard to maximize its objective function (4.18). Each possible level of this standard corresponds to a certain level of producer and retailer profits, and hence also to a certain level of producer and retailer contributions. This is driven by the functional form and the truthfulness of the contribution schemes that show that the government will receive higher contributions from producers (retailer) if the imposed standard creates higher producer (retailer) profits. Conversely, the government receives less producer or retailer contributions if the standard decreases their respective profits. Therefore maximizing these contributions from producers (retailers) by choosing the level of standard is equivalent to maximizing their respective profits. The government will thus choose the level of standards such that it maximizes the weighted sum of producer profits, retailer profits, and social welfare. The politically optimal standard, s^g , is therefore determined by the following first order condition, subject to $s^g>=0$:

$$\frac{\partial V(s^g)}{\partial s} = (1+\alpha^p)\frac{\partial \Pi^p(s^g)}{\partial s} + (1+\alpha^r)\frac{\partial \Pi^r(s^g)}{\partial s} + \frac{\partial \Pi^c(s^g)}{\partial s} = 0$$
(4.19)

Using the reduced form expressions (4.12) to (4.14), equation (4.19) can be rewritten as

$$\left(\frac{3}{2}+\alpha^r\right)\cdot q^*(s^g) + \frac{\partial q^*(s^g)}{\partial s}\left[3s^g + 4k + 2\alpha^p k + 2\alpha^r(s^g + 2k)\right] = 0$$
(4.20)

where $q^*(s^g)$ is the market equilibrium output (equation (4.11)) evaluated at $s = s^g$. Expression (4.20) contains the solution for s^g, i.e. the politically optimal public standard, given that the sector is at equilibrium.

4.4 The retailer' optimal private standard

Since the politically optimal public standard is determined in a political process in which the government also takes the aggregate social welfare and producers' contributions into account when determining its optimal policy, the politically optimal public standard is not necessarily at the level desired by the retailer. Define s^r as the retailer's optimal public standard, i.e. the level of the public standard which maximizes the retailer's profits, given the market equilibrium as described earlier. By definition, we have that at the retailer's optimal public standard, s^r ,

$$\frac{\partial \Pi^r\left(s^r\right)}{\partial s}=0 \tag{4.21}$$

Evaluating Equation (4.19) at the retailer's optimal standard, s^r, instead of the government's politically optimal standard, s^g , using Equation (4.21), results in

$$\frac{\partial V\left(s^r\right)}{\partial s}=\left(1+\alpha^p\right)\frac{\partial \Pi^p\left(s^r\right)}{\partial s}+\frac{\partial \Pi^c\left(s^r\right)}{\partial s} \tag{4.22}$$

It is straightforward to see that expression (4.22) is not necessarily equal to zero, which implies that the government's politically optimal standard and the retailer's optimal standard are at different levels. If and only if under the specific circumstance that $\left(1+\alpha^p\right)\frac{\partial \Pi^p\left(s^r\right)}{\partial s}=-\frac{\partial \Pi^c\left(s^r\right)}{\partial s}$, then $\frac{\partial V\left(s^r\right)}{\partial s}=0$

and thus $s^r = s^g$. However, if $\frac{\partial V(s^r)}{\partial s} > 0$, given that the government's objective function is strictly concave $\left(\frac{\partial^2 V}{\partial s^2} < 0\right)$, we have that $s^r < s^g$. Vice versa, if $\frac{\partial V(s^r)}{\partial s} < 0$, it must be that $s^r > s^g$.

Therefore, if $\frac{\partial V(s^r)}{\partial s} < 0$, the retailer has an incentive to impose its own private standard[22]. We assume that this private standard regulates the same product characteristics as the public one (e.g. pesticide residues) but may differ in its level of stringency (e.g. the maximum allowed residue level). As we assume that the monopolist retailer has market power over producers and consumers, the retailer is able to impose this private standard unilaterally. The retailer is the only intermediary agent between producers and consumers and therefore producers have no other option than to adhere to this private standard if they want to sell their products through this retailer. This private standard can therefore be interpreted as a 'de facto' public standard[23], although it is issued by a private organization i.e. the retailer.

Therefore, the retailer's optimal private standard equals the retailer's optimal public standard, s^r. Hence determining whether the retailer has an incentive to set a private standard at a higher level than the public standard boils down to following the above procedure, i.e. assessing whether $\frac{\partial V(s^r)}{\partial s} < 0$ given that

[22] Naturally, producers have to abide by the most stringent standard, be it the public or private one. Hence, when the retailer's optimal private standard is lower than the public standard, the retailer has no incentive to impose its private standard.

[23] This needs a reference to GlobalGAP and BRC standards (Henson, 2006): these are examples of such private standards that are, or have become, 'de facto' public standards, although issued by retailers.

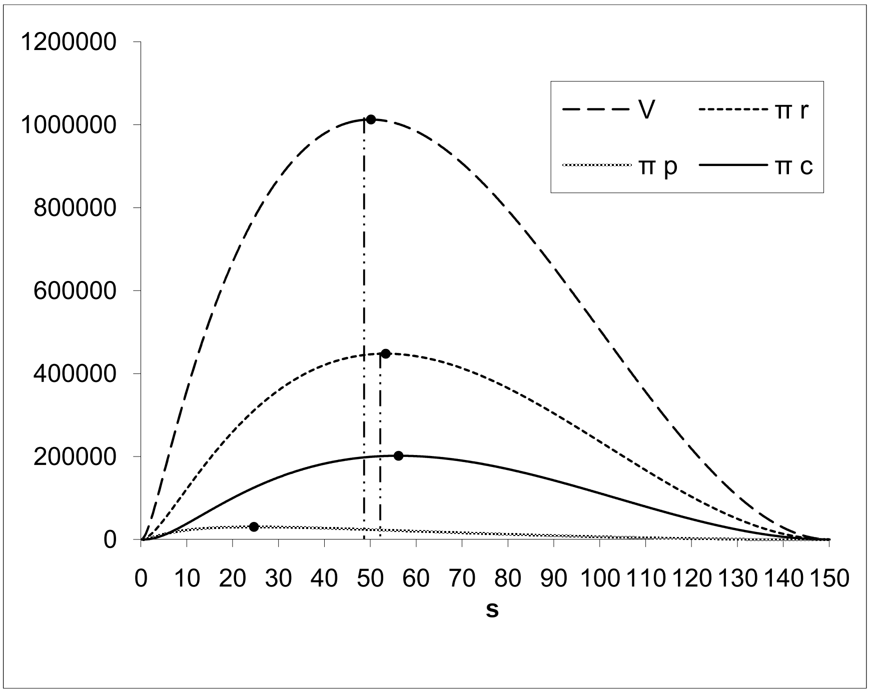
$\frac{\partial \Pi^r\left(s^r\right)}{\partial s}=0$. Equivalently, one may also assess whether $\frac{\partial \Pi^r\left(s^g\right)}{\partial s}>0$ given that $\frac{\partial V\left(s^g\right)}{\partial s}=0$ and $\frac{\partial^2 \Pi^r}{\partial s^2}<0$.

4.4.1 Comparing the optimal public and private standards – a numerical example

Assessing whether $\frac{\partial V\left(s^r\right)}{\partial s}<0$ involves evaluating for which ranges of parameter values we find that $\left(1+\alpha^p\right)\frac{\partial \Pi^p\left(s^r\right)}{\partial s}<-\frac{\partial \Pi^c\left(s^r\right)}{\partial s}$. For now, we consider one numerical example which shows the possibility of this result. We assume that k=3, c=4, Φ=300, α^p=5 , and α^r=0.5. Hence we assume that producers have more political power than retailers, which is crucial in our argument.

Figure 4.1 shows the producers' profits, the retailer's profits, aggregate consumer surplus and the government's objective function's value for given levels of the standard s under the aforementioned parameter values, by inserting the latter values in the reduced profit functions in Expressions (4.12) to (4.14). The maxima of the different functions are marked with a dot in Figure 2. It is easily observed from Figure 4.2 that the government's politically optimal standard s^g=50.1, whereas the retailer's optimal private standard s^r=53.3 , such that s^r>s^g. Hence, given our assumptions, it is optimal for the retailer to set a private standard that is more stringent than the public one. The driver of this result is that the producers have sufficient political power to influence the government to set lower public standards, while the retailer has sufficient market power to impose its private standard unilaterally.

Figure 4.2: Numerical example



It is clear from Figure 4.1 that the private standard sr , which is larger than the public standard s^g, is suboptimal for both producers and consumers. At s^r, we have that $\frac{\partial \Pi^c\left(s^r\right)}{\partial s} > 0$, implying that the private standard is not sufficiently stringent for consumers. We also note that at s^r, $\frac{\partial \Pi^p\left(s^r\right)}{\partial s} < 0$, showing that the private standard is too stringent from the producers' perspective. Although these observations also hold at the government's politically optimal public standard s^g, the private standard is more aligned to the consumers' optimal level away from the producers' optimal level, since the retailer can exercise its market power by unilaterally setting its private standard. In contrast, the government takes the producers' interests into account, and sets a lower public standard if producers have sufficient political power (a^p sufficiently large).

4.5 Evidence from retailers' private GMO standards

In this section, we provide an empirical application to show how our model's predictions fit the real world through a case study on retailers' GM standards. For this purpose we have collected information directly from food retailers. We have analyzed GM-free private standards set by supermarkets from a global perspective. We focus on GM standards given the relevance and sensitivity of this issue, both politically and commercially, in developed as well as developing (emerging) countries.

4.5.1 Sample selection

We have obtained information from 45 retailers groups, consisting of 183 different supermarkets brands including all types of stores from hypermarkets to express stores. 26 groups are based in Europe, 16 in North America (United States and Canada) and 3 in the oriental hemisphere (Asia and Oceania). Our sample represents 75% of the top 100 world food retailers (Deloitte, 2009) (in table 4.1 the complete list of retailers).

We have applied three different strategies to gather data. Because no univocal GM standard, neither public nor private, has been internationally diffused or implemented yet[24], we refer to retailer statements on their (internal) GM policy, collected from retailers' web pages, and annual financial and sustainability reports. For missing information or ambiguous statements we contacted the retailers' customer services directly.

[24] Exceptions are 'Cert ID', which is adopted by producers but not by retailers, and a partial auditing control by 'GlobalGAP' which includes a voluntary traceability system.

Tab. 4.1: List of retailers groups and private GM standards

	Home Country	*Retailer*	*Main Markets*	*GMO Private Standard*
1	GER	Aldi Group	Europe, United States	GMO-free
2	FRA	Auchan Group	Europe	GMO-free
3	FRA	Carrefour Group	Europe, South America	GMO-free
4	FRA	Casino Group	Europe, South America	GMO-free
5	AUS	Coles Group	Australia	GMO-free
6	ITA	COOP Italia scarl	Italy	GMO-free
7	CHE	Coop Schweiz	Switzerland	GMO-free
8	FRA	Cora Group	Europe	GMO-free
9	BEL	Delhaize "Le Lion"	United States, Europe	Potential use of GM ingredients
10	USA	Dollar General	United States	Potential use of GM ingredients
11	GER	Edeka Group	Germany	GMO-free
12	ITA	Esselunga	Italy	Potential use of GM ingredients
13	USA	Giant Eagle	United States	Potential use of GM ingredients
14	USA	Hyvee	United States	Potential use of GM ingredients
15	SWE	ICA Group	Sweden, Norway	Potential use of GM ingredients
16	GBR	J Sainsbury	Great Britain	GMO-free
17	FIN	Kesko Ltd	Finland	None objections to GM ingredients
18	FRA	E. Leclerc	Europe	GMO-free
19	CAN	Loblaw Companies Limited	Canada	Potential use of GM ingredients
20	JPN	Seven & I Holdings Co.	Global	Potential use of GM ingredients
21	GBR	Marks & Spencer	Global	GMO-free
22	ITA	Mdo Spa	Italy	GMO-free
23	USA	Meijer	United States	Potential use of GM ingredients
24	GER	Metro Group	Global	Potential use of GM ingredients
25	CHE	Migros Group	Switzerland	GMO-free
26	GBR	Morrison Supermarkets	Great Britain	GMO-free
27	USA	Nash Finch Company	United States	Potential use of GM ingredients
28	USA	Publix Supermarkets	United States	Potential use of GM ingredients
29	GER	Rewe Group	Germany, Austria	Potential use of GM ingredients
30	USA	Roundy's Supermarkets	United States	Potential use of GM ingredients
31	NLD	Koninklijke Ahold	United States, Nederlands	None objections to GM ingredients
32	USA	Safeway	North America	None objections to GM ingredients
33	ITA	Selex Group	Italy	Potential use of GM ingredients
34	USA	ShopRite	United States	Potential use of GM ingredients
35	CAN	Sobeys	Canada	GMO-free
36	GBR	Somerfield Stores	Great Britain	GMO-free
37	USA	SuperValu	United States	Potential use of GM ingredients
38	FRA	Systeme U	France	GMO-free
39	GER	Tengelmann Group	Germany	GMO-free
40	GBR	Tesco	Global	GMO-free
41	USA	The Kroger Company	United States	Potential use of GM ingredients
42	USA	Walmart Stores	United States, South America	Potential use of GM ingredients
43	USA	Whole Foods Markets	United States	GMO-free
44	USA	Winn-Dixie Stores	United States	Potential use of GM ingredients
45	AUS	Woolworths Limited	Oceania	Potential use of GM ingredients

Source: own data collection. See text for explanation.

We focus specifically on GM-free standards imposed on retailers' own brand products, because these products represent a direct link between supermarkets and producers, stressing the monopsony that small producers face due to the strong market power of retailers. Organic products are treated separately since these products are subject to certification processes that do not allow the use of GM ingredients.

4.5.2 Evidences

The 45 retailer groups in our sample have stores in 80 countries distributed over all continents (see Table 4.2). European retailers have a wider geographical diffusion with stores in 74 countries distributed over all continents. In contrast, North American retailers are mainly focused on their domestic market, since they are present in only 15 countries. This may be due to different domestic market dimensions. US retailers can rely on a larger domestic market, which reduces internal competition and the need to consider internalization as a growth strategy. The North American retailer most active in foreign markets is Walmart. It is also the largest retailers in terms of annual revenues, and additionally invests in several developing and emerging countries.

We divide retailers into three categories based on their statements about GM products and ingredients (see Table 4.1). We identified retailers with a GM-free standard, retailers that potentially adopt GM ingredients, and retailers that have no objection to the use of GM.

Retailers with a GM-free standard are those who have decided not to use GM ingredients in their own brand products. They declare to have a GM-free policy supported by third-party certification or guaranteed by an NGO such as Greenpeace. Some GM-free standards are essentially bilateral contracts with producers, which impose the supply of products free of GM.

Retailers considered as potentially adopters of GM are those who basically comply with public GM standards. Broadly speaking, there are two approaches to regulate GM with a public standard. The first is a voluntary label on the presence of GM ingredients, in line with for example the substantial equivalence approach adopted in the United States. The second option is a mandatory GM label when the content of GM ingredients exceeds a certain threshold, in line with for example the European precautionary principle. The European threshold above which a product must have a GM is set at 0.9%, while this threshold is 1% in China, Australia and Brazil, 3% in South Korea and Malaysia, and 5% in Japan and Indonesia.

Tab. 4.2: Number of countries divided per geographical regions where our sample' retailers groups holds stores

Destination Markets	*Developing\Emerging*	*Developed*	*Tot*
Africa	6	7	13
Asia	8	6	14
Europe	11	23	34
Middle East	2	1	3
North America	0	2	2
Oceania	0	2	2
South America	12	0	12
Tot	**39**	**41**	**80**

In line with their public regulation, retailers in North America are not obliged to label their products. Hence we do not have reliable information about the content of GM ingredients in retailers' brand products. Nevertheless, if no GM policy is mentioned, it is likely that their products contain GM ingredients due to the diffusion of GM crops and to weaker consumers concerns about GM in these countries.

European retailers who comply with the public standard are allowed to use GM ingredients approved in the European Union, but must put a label on their products if the GM content is larger than 0.9%. For European consumer who are more concerned about the effect of GM on human health and the environment, a GM label acts as a hazard warning (see Chapter 3), discouraging retailers to sell GM labeled products. The result is that many retailers in Europe decide to remain below the regulatory threshold to preserve their public image. In the same time however they do not exclude the possibility of using GM. Hence, most European retailers tend to set the GM content in their own brand products below the labeling threshold, i.e. apply a de facto stricter standard.

In our sample there are 21 retailers with a GM-free statement (Table 4.3), most of them from Europe. Taking into account that most European retailers included in the "potential adoption of GM" category remain under the 0.9% threshold, we find that in Europe GM private standards are stricter than public ones, in line with our political economy model.

However, this is not the case for North American retailers. In line with public regulation, US and Canadian supermarkets do not adopt specific standards on GM, neither do they have specific statements on their use[25].

Tab. 4.3: Number of retailers per GMO private standard and geographical regions.

	Numbers of Retailers		
Origin	GM Free	Potential Adoption of GM	None objections to GM ingredients
Europe	18	6	2
North America	2	13	1
Asia - Oceania	1	2	0
Total	21	21	3

Source: Retailers statements on Webpages, Annual Reports and private comunications.
Notes: Total sample of 45 retailers

The top ten world retailers included in our sample (Table 4.4) are divided over the categories GM-free retailers and potential use of GM ingredients. None of them are oriented to the use of GM.

Retailers' private policies may change in geographically different markets, adopting the best strategy in line with

[25] Exceptions are the 'Whole Food Market' which sells only organic products, and the 'O' line products of Sobeys which is a special brand of organic products.

consumer preferences and the public standard. For example Tesco, which has its core business in Europe, adopts a GM-free standard globally but with the exception of China and US. In these countries Tesco allows the use of GM ingredients. In the same way Delhaize avoids adopting specific GM standards, except in Europe where Delhaize sells under a GM-free private label (Annex 1).

Moreover, some retailers belonging to the same group apply different approaches. The case of ASDA is particularly important because is a sub retailer of the Walmart Group, the global leader in food retailing. Walmart has stores all over the world, but only in Great Britain it has implemented a GM-free standard under the brand of ASDA. Also DIA has a slightly different approach compared with the mother group Carrefour which sells GM-free private label products. DIA declares to comply with public regulation, which is not necessarily GM-free.

Surprisingly also hard discounters like ALDI have a GM-free statement. Hard discounters sell cheaper products and usually have less (or lower) private standards. However, since the global economic crises of 2008-2009, the retailers' strategies to increase sales is both to implement their discount format and to focus on value-oriented consumers. In this context hard discounters are shifting to higher quality products in order to capture a larger share of consumers.

Finally, there are some retailers that have no objections to the use of GM ingredients.. The retailer Safeway states to be in favor of GM if the GM ingredients are considered safe for human health. Also two European retailers (Kesko and Royal Ahold) are willing to use biotechnology products, provided this is in line with consumer demand.

Tab. 4.4: GMOs private standards of the top 10 world retailers in our sample. In grey GMO-free retailers.

Home Country	*Retailer*	*Main Markets*	*Private Lable Products*
USA	WalMart	USA Latin America Asia	Potential use of GM Ingredients
FRA	Carrefour	Europe Latin America	GMO-free
GER	Metro	Europe	Potential use of GM Ingredients
UK	Tesco	Europe Asia	GMO-free
USA	The Kroger	USA	Potential use of GM Ingredients
GER	Aldi	Europe USA	Potential use of GM Ingredients
GER	Rewe	Europe	Potential use of GM Ingredients
FRA	Auchan	Europe	GMO-free
JPN	Seven & I Holdings	Asia	Potential use of GM ingredients
FRA	E. Leclerc	Europe	GMO-free

Source: own data collection. See text for explanation.

4.6 Conclusions

In this paper we have shown that if producers have sufficiently more political power than the retailer, the latter may use its market power to unilaterally set a private standard at a higher level than the public standard. We argue that a retailer is willing to set its private standard at a higher level than the public standard if consumers value the quality attributes assured by the private standard and if the retailer has sufficient market power to pass the standards' implementation costs on to the producers. Unlike the private standard, the public standard is assumed to be determined in a political game where producers, retailers, and consumers have some political power to influence the standard-setting process. Since producers bear (most of) the implementation costs, they contribute in favor of a lower public standard. Because of their political power, the resulting public standard is set at a lower level than the private one, which is the level preferred by the retailer. Hence our model combines both aspects of retailers' market power and producers' political power to explain why private retailers' standards may be set at higher levels than public standards.

Additionally, we provide an empirical application to show how our model's predictions fit the real world through a case study on retailers' GM standards., based on a survey among a sample of 45 retailer groups. Consistent with the model's prediction, we find that in Europe private standards on GM ingredients are stricter than public standards for a large number of supermarkets, while in the US retailers sets standards according with public regulation.

Finally, we observed that some retailers adopt different standards in different countries, setting the level of restrictiveness according to the consumers' preferences and public regulation of the country where they are operating, in order to optimize their commercial strategy.

Conclusions

The aim of this study is to investigate the role of standards in the international agri-food market from a political economy perspective. We analyzed both public and private standards related to genetically modified organisms (GMOs). GMOs are currently a sensitive issue for food production, safety and international trade.

Producers and exporters countries with a comparative advantage in agriculture and food production tend to use GMOs to reduce production costs and obtain higher yields. Often, they set permissive public regulations enhancing an extensive adoption of this biotechnology. On the other side, consumers and importers of agri-food products raise concerns about the safety of GMOs as well as about ethical issues.

Public regulation in these countries is more restrictive and may act as a non-tariff barriers (NTBs), or protection in disguise. Furthermore, food retailers have recently adopted their own private standards, directly communicating to consumers the content of GMOs in their products. Retailers are the last link in the agri-food chain and they use private standards for vertical differentiation strategy. In the same time private standards' adoption affect public regulations. Policymakers take into account present private standards when setting public standards, in order to avoid economic burden on firms. Moreover, in less developed countries without public food standards, private standards often became the reference for policymakers.

We provided definitions and classifications of standards, as well as an overview of the methods used in the literature to analyze the effect of standards on international trade and to investigate a suitable strategy for assessing the effects of GMOs regulation. What emerged is a problem related to the measurement of standards for the assessment of their effect as NTBs. To overcome this problem we treated public and private GMO standards with two different strategies, taking into account their specificities.

To investigate the role of GMOs public standards, we developed a composite index for 60 countries distributed in all continents. The index is obtained by assigning a score to each component of the GMO regulation. We identified six components of the regulation: approval process, risk assessment, labeling, traceability system, coexistence and membership in international agreements. The overall index is obtained by score summation and normalization, so that it ranges between 0 and 1. Higher values correspond to more stringent regulations.

We studied the socio-economic determinants of GMOs regulation among country pairs. We calculated two different measures of the bilateral GMO index, namely $GMOw_{ij}$ and $GMOd_{ij}$, for comparison purposes. Explanatory variables are classified in three groups: trade costs, institutional differences and economic controls. Our econometric strategy is to compare three different OLS regression specifications. The first is a pooled specification, in the second we include country fixed effects and in the third we include country fixed effects coupled with a dummy variable controlling for EU membership. Results showed that health expenditure and trade flows are significant determinants of similarity in GMO standards. Differences in health expenditure lead to different GMO regulations. Countries with different health systems and health protection investments may also adopt dissimilar GMO standards. Moreover, highest bilateral trade of major GM crops induce countries to set similar regulations. This leads to the formation of commercial sub-agreements that reduce the protectionist impact of GMO regulation. Finally, tariffs are an important determinant of GMO standard harmonization, even if less stronger. They have a negative impact on harmonization, meaning that the absence of tariffs promote a stronger reduction of trade protectionism through similar GMO regulation.

We used the bilateral GMO index to analyze the effect of GMO regulation on bilateral trade flows of agricultural products. We empirically investigate the way bilateral similarity/dissimilarity in GMO regulation affects trade flows. Econometrically, we used a gravity model controlling for sample selection bias dealing with zero trade flows. Moreover, we instrumented the dependent variable to control for endogeneity. Three main results are shown. First, countries with greater differences in GMO regulation trade significantly less. The level of harmonization of the GMO regulation is important to boost trade flows. From the observation of the GMO index, we see that countries create groups or 'clubs' which share similar GMO regulations. Second, among the six regulatory dimensions, labeling system, approval process and traceability requirements are the most important. Third, our tests of the endogeneity of GMO regulations to trade flows showed that simultaneity bias is potentially important. The effect of endogeneity largely dominates in magnitude (about four times) the traditional selection bias problem.

Private standards have been theoretically investigated through a political economy model. Our aim is to understand why private standards are often more stringent than public ones, a question often underlined in the economic literature. Additionally, we provide an empirical application to show how our model's predictions fit the real world through a case study on retailers' GM standards. The model combines both aspects of retailers' market power and producers' political power to explain why private retailers' standards may be set at higher levels than public standards. If producers have sufficient political power, they lobby for a certain level of public standards. Because they bear most of the implementation costs, they contribute in favor of a lower public standard to reduce production costs. The retailer may use its market power to unilaterally set a private standard at a higher level than the public one. The public standard is assumed to be determined in a political game: producers, retailers, and consumers have some political power to influence the standard-setting process. The resulting public standard is set at a lower level than the private one. To provide evidences on this theoretical result, we conducted a survey collecting information on GMOs private standards among a sample of 45 retailer groups. The findings are consistent with the model's prediction. First, a difference between Europe and US emerges. In Europe, private standards on GMO ingredients are stricter than public standards for a large number of supermarkets, while in the US retailers set standards according with public regulation. Furthermore, retailers' strategy varies in different countries. The level of restrictiveness varies accordingly to consumers' preferences and to public regulation of the country where retailers are operating.

Overall, results showed that standard stringency is not the only factor affecting trade. Also the similarity in requirements play an important role. There are some components of the public regulation that have a major effect on trade flows. For example, labeling affects directly consumer purchase because it can act as a hazard warning on the content of GMOs. Labeling is important also for private GMO standards, because retailers exploit labels also to communicate their strategy to conduct business. This has a great appeal on sensitive issues, such as the GMOs one, in rich countries where consumers demand higher food quality. Other components, such as the approval process, can impede trade. Indeed only approved GM crops can be imported and retailers must comply with this requirement without any possibility of intervention. Traceability between traditional, GM and organic products increase production costs due to the segregation requirements and transfer of information along the food chain. Nevertheless, traceability is also a strategy of private firms for differentiation of products' quality.

The main policy implication of our results is that a process of harmonized international standardization could have a positive trade effect. This is especially true with regard to labeling policies. Standards harmonization efforts has already been done, both at private and public levels. For example, private firms create the coalition GFSI to reduce transaction costs and, from the public side, the EU members share similar standards. The potential benefits of harmonization push developing countries to set similar standards with those of rich countries, in order to gain or maintain market access. Many less developed countries followed this strategy, but is not clear if it is the most suitable option for their development plans. Indeed, others developing countries have not yet determined their 'welfare maximizing' standards and they adopt the so called 'wait and see' strategy where standards are still undefined. This reticence to take a *pro* or *contra* position can be motivated by the fear of losing access in important markets. Producers in developing countries tend to comply with private standards to gain supply enrollment, obtaining in the same time access to rich markets. Producers often shift from smallholders contract-farming to large-scale agro-industrial farming. Private standards act as catalyst for the modernization of developing countries' agriculture and improve their competitiveness.

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Annexes

Annex 1: Examples of retailers statements. In grey strategies of differentiation depending on market and supermarket brand.

Retailer	Home Country	Main Markets	Statement on GMOs	Source
ALDI Australia (ALDI Group)	Germany	Europe USA	"We have achieved 'green' status for our Genetically Modified policy in Greenpeace's True Food Guide. ALDI complies with all existing regulatory requirements pertaining to GM as stated in the Australia New Zealand Food Standards Code. ALDI does not stock any products which are labeled as containing GM ingredients."	ALDI Australia Website
DIA (Carrefour Group)	France	Europe	"Dia complies with current legislation, guaranteeing that its products do not consist of, nor have they been produced from, ingredients that contain more more than 0.9% GMO. To guarantee its compliance, the company demands certificates from all its suppliers and carries out periodic analyses of all its products."	DIA Annual report 2007
Delhaize "Le Lion"	Belgium	USA Europe	"In Belgium, Greece and the Czech Republic, Delhaize Group has introduced GMO-free private label products, offering its customers the choice between products with or without GMOs […] Delhaize determines, again in close cooperation with the authorities, the appropriate food labeling."	Delhaize Annual Report 2001
Kesko	Finland	Finland	"Kesko says that it keeps a close eye on the development of the legislation concerning the use of genetic engineering and the latest data and products available. Special attention is paid to products offering added value to consumers. If required, Kesko can participate in the research involving GM plant varieties and products. Kesko's decisions on selections are based on consumers' needs and wishes; Kesko can thus include in its ranges such GMO products whose safety has been duly confirmed in the way required by authorities. So far, Kesko has had no GMO foods (or foods containing GMO ingredients) in its selections."	Corporate Responsability Report 2009
Royal Ahold	Netherlands	USA Netherlands	"Where there are clear, demonstrable benefits to consumers, Ahold has no objections to the responsible use of safe biotechnology. Products we offer which are made with this technology are products which are approved by the authorities, based on a safety and environmental impact assessment. We differentiate our assortment from country to country in line with consumer demand."	Ahold Website

Retailer	Home Country	Main Markets	Statement on GMOs	Source
Safeway	USA	USA Canada	"Today's agricultural and food industries are using genetic engineering to develop new and better foods and food-related products.[…] You may not be able to tell when you're buying GM foods, because the FDA generally doesn't require manufacturers and producers to label them as such."	Safeway Website
Tesco	UK	Europe Asia	"In China and the US we do allow some GM ingredients in our own-brand products." […] "We have a non-GM ingredient policy for our own-brand foods in 11 of the countries in which we operate"	Corporate Responsability Report 2009
ASDA (Walmart)	USA	Great Britain	"Our buying team have listened to our customers' feedback on this issue and they have told us that they have some concerns about Genetically Modified ingredients. We have therefore taken action in line with their concerns and have now successfully removed GM protein and protein derivatives from all ASDA own brand products."	Personal communication
Coop Italia	Italy	Italy	"Coop has decided not to use GMOs in the manufacture of own brand products and has developed a system of guarantees (the BVQI certificate) to ensure the consumer does not use corn, soybeans and their derivatives GM."	Coop Italia Website

Source: own data collection.

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