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Measure the measure: the impact of differences in pesticide MRLs on Chilean fruit exports to the EU

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Abstract:

This paper advances the measurement of nontariff measures (NTMs) by discussing a framework for how to compare regulations. We argue that relative differences in SPS regulations trigger the impact on trade flows between trading partner countries and specifically look at maximum residue levels (MRLs) for pesticides in a case study on Chilean fruit exports to the EU. In order to capture the relative differences and stringency in tolerance levels of trading partners, a simple indicator is constructed and applied in an econometric analysis. In comparison to existing indices of regulatory heterogeneity, the depth of information generated by our indicator severely compromises its coverage. Further development of our heterogeneity index will need to aim at including elements of process standards and conformity assessment procedures.

Key words: regulatory differences, index for pesticide MRLs, agri-food trade, econometric analysis
JEL classification: Q17, F19, C23

1. Introduction

Advances in the measurement of impact of nontariff measures (NTMs) on trade and competitiveness are constrained by the lack of consistent data on regulatory differences between countries. In previous studies on the impact assessment of NTMs, in particular standards and regulations, various indicators to measure NTMs have been applied. In several studies frequency and coverage measures have been used, often based on count data from the TRAINS dataset of the UNCTAD. Whereas such indicators have many shortcomings, a critical flaw is the lack of information on the standards and regulations themselves. Recent contributions to the literature indicate that the economic impact of standards and regulations will differ by the type and purpose of the measure under review. Korinek, Melatos and Rau (2008) discuss different measurement methods and provide an overview of the existing literature. The analytical framework developed by OECD (2008) encompasses the costs and benefits of regulations and standards in the impact measurement, thereby taking into account the purpose of the measures. For useful applications, data on the scope and purpose of regulations and standards is necessary.

Apart from some detailed case studies, few quantification studies take into account the substance of regulations and standards but usually the relative differences between regulations in the home and export country is not explicitly considered. In international trade, NTMs can constitute entry barriers due to the additional costs for exporting firms. The key question thus is whether exporters incur additional market entry costs, and in this regard differences in regulation between the home regulation and the import requirements matter more than the absolute stringency of the regulation. A promising tool for expressing the stringency in such relative terms is an index of regulatory heterogeneity that measures to what extent relevant regulations in country A differ from those in country B.

This paper presents on-going research that seeks to identify differences in NTMs in order to quantify their trade impact. Converting qualitative information of regulatory regimes for food safety into appropriate indicators is challenging, and we therefore focus on maximum residue levels (MRLs) for pesticides. In our case study, we look at pesticide MRLs for exports of fresh fruit from Chile to the European Union (EU). The EU-Chile case study is particularly interesting in the context of bilateral trade reform and cooperation on standards and regulations. The free trade agreement between the EU and Chile contains specific provisions for cooperation on standards, technical regulations and conformity assessment (Annex IV of the EU-Chile Association Agreement). Although the agreement promotes the mutual recognition of requirements and procedures of dealing with SPS issues in order to avoid and/or reduce possible trade impediments for both Chilean and EU agri-food exporters, differences can be expected to continue to influence agri-food trade between Chile and the EU member states.

The structure of the paper is as follows: First, we briefly outline a framework for comparing standards and regulations across countries. After some information on fruit trade between Chile and the EU, we introduce the case study of pesticide MRLs that Chile and the EU respectively impose on a set of selected fruits and construct a regulatory heterogeneity index. The index is subsequently applied in an econometric model of the Chilean export supply of fruit to the EU15. The paper ends with some conclusions on both methodological advances and the policy implications of the estimation results.

2. Comparing regulations and standards in trade

The regulatory system to control food safety and health issues consist of various elements amongst which requirements, conformity assessment and enforcement constitute the basic elements. These basic elements to control food safety are embedded in the overall institutional and/or organizational system that stands at the top level of the framework of regulations for food safety and other quality aspects. While the responsibilities of governmental agencies, private entities and expertise may be differently distributed in different countries, the institutional and organizational framing of governmental regulations shapes the standard setting, the implementation of standards and their enforcement.

Governmental food safety and quality regulations are formulate in the national food law of the respective country. While domestic producers have to meet mandatory governmental requirements, governments also demand that foreign products satisfy the respective requirements as import conditions. Non-compliance with the requirements by the importing country can reduce or entirely block the foreign market access, thereby affecting the volume of exports as well as the export destination. The regulatory system of food safety and quality is in the first instance a domestic affair, often with some kind of international coordination though. In international agri-food trade, requirements and conformity assessment however also apply to foreign products and are hence considered as non-tariff measures (NTMs).

Following the new classification of NTMs of the database of the Trade Analysis and Information System (TRAINS)[1], we differentiate between actual requirements and conformity assessment that are specified for SPS regulations on the one hand and technical regulations (TBT) on the other hand. While requirements contain both product and process standards, conformity assessment relates to the evaluation, verification and the assurance of conformity. Conformity assessment requirements comprise testing and inspection requirements as well as approval procedures, including the accreditation and pre-listing of exporters and/or products allowed to be sold on the market of the respective importing country. Quarantine measures ensuring that unwanted foreign species and pests are not imported can also be considered as some kind of conformity assessment. Table A1 in the appendix provides an overview of SPS requirements defined by the new TRAINS classification. We argue that differences in standards and regulations determine the trade impact and therefore compare standards and regulations in our analysis.

At the international level, the relation between requirements for domestic and foreign products is organised by the WTO trade rules, more precisely the SPS and TBT Agreement. While maintaining the sovereign right and obligation of countries to set their own standards, countries are encouraged to base their import requirements on internationally agreed standards, in the case of food safety for example the standards and guidelines developed by the Codex Alimentarius Committee of the World Health Organisation[2]. If measures are used to protect human, animal and plant health in the

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[1] A Multi-Agency Support Team (MAST) was recently established to improve the TRAINS database of the United Nations Conference on Trade and Development that reports the number of notifications of NTMs. MAST developed an improved classification of NTMs used for the updating of the TRAINS database.

[2] The Codex Alimentarius refers to food standards, guidelines and codes of practice recommended under the Joint FAO/WHO Food Standards Programme. The International Pant Protection Convention

importing country and are not misused as disguised protectionist measures in favour of domestic producers, the SPS Agreement foresees the possibility of different requirements for foreign food products. In order to impose different and possibly tighter standards on foreign products importing countries are required to provide scientific risk assessments, thereby justifying the necessity of the respective requirements. Furthermore, requirements have to be commensurate with their objectives and least trade-distorting for achieving the objective aimed at. If the aforementioned criteria are fulfilled, importing countries can on the hand uniformly impose stricter standards on imports from all exporting countries or require that products from different countries satisfy different requirements in order to control for export specific risks. In the latter case for example, products from certain countries may need to be specifically treated (e.g. irradiation treatments) before importing so as to reduce the risk of introducing pests that are endemic in the respective exporting countries but not in the importing country.

Although countries can demand different and possibly tighter standards for foreign products according to the SPS Agreement, domestic requirements generally constitute the basis for import requirements. Difference in domestic and foreign market requirements for agri-food products are due to several reasons: On the one hand, standards requirements reflect institutional structures and the national food law, and on the other hand, they reflect the prevalent production systems that depend on local circumstances (e.g. natural conditions, R&D activities), and consumption traditions (e.g. diets, consumer preferences, acceptable risk tolerance levels). Given the regulatory differences across trading partner countries, the requirements demanded by importing countries can be stricter than those in exporting countries.

From the producers' point of view, the requirements for supplying the domestic market and foreign export markets matter. That is, exporters have to satisfy the requirements of importing countries in order to sell their products on foreign markets. Complying with stricter import standards obviously leads to costs for exporters, and those exporters that whish to sell their products on different foreign markets tend to face even higher costs because they have to comply with several standards according to the export destination. To quantify the trade effects of standards, these costs are typically approximated but the benefits of standards for producers, for example improved production efficiency and higher quality products for which producer can usually obtain higher prices, are often neglected. Furthermore it has to be noted that trade may not at all take place without standards that reduce the risks of exchanging products in general and agri-food products in particular.

This paper does not elaborate on the costs and benefits of standards in international agri-food trade, but for our analysis we argue that the mere difference between the standards required for supplying the domestic and foreign market determine the trade impact. Our case study specifically looks at pesticide MRLs as import requirements in the case of fruit trade between Chile and the EU.

(IPPC) and the World Organization for Animal Health (OIE) respectively promote international standards and guidelines to prevent the introduction and spread of plant and animal pests.

3. Fruit trade between Chile and the EU: the case of maximum residue levels (MRLs) for pesticides

3.1. Fruit trade between Chile and the EU

Agri-food trade between the EU and Chile has rapidly expanded since the early 1990s, up to a total volume of trade of over 2.5 billion euro in 2007. The Chilean exports to the EU outstrip the EU export to Chile by a factor of ten. Chile's main export products are fresh fruit, other products exported include wine and marine products. Fresh fruits exports reveal a combination of expanding volumes and at the same time declining importance in the export portfolio. The case study in this paper examines whether differences in pesticide MRLs between Chile and the EU explain why the growth rates of fruit exports to the EU have lagged behind other agri-food exports.

In 2002, the EU and Chile signed a free trade agreement (FTA), within the framework of the EU-Chile Association Agreement. Before the FTA the EU tariffs for Chilean products were determined under the Generalized System of Preferences (GSP). Chile, which here competes with the North African countries and other Latin American countries for market share in the EU export market, received very limited preference margins. Under the EU-Chile Association Agreement Chile benefited from 1 January 2004 onwards of deeper preferences for access to the EU market. In the agreement, the EU committed to gradually phase out most tariffs on agricultural imports from Chile between 2004 and 2013. In order to allow for adjustment in the sub-sectors most sensitive to import competition, the EU phases in tariff eliminations over a maximum of 10 years. The mechanisms of the FTA for EU imports of Chilean fruit are to eliminate all ad valorem tariffs by 2013, while maintaining the specific tariffs (i.e. tariffs expressed on the basis of weight). Complete tariff elimination is phased in between 2004, the year the agreement went into force, and 2013 in 4 clusters of tariff lines. In fact, the 10-year phase-in time is little used and applies only to oranges in fall and winter and for table grapes during the European summer. The earliest elimination of tariffs, by 2004, applied to nuts, off-season oranges, off-season apples, raisins, melons, and most preserved fruits.[3] The seasonal schedule of import duties is designed to protect European producers from import competition during harvest season. It is much less a factor for competitors in southern hemisphere countries.

Apart from a possible seasonal variation in the import tariff, the EU maintains an entry price system to reduce import competition during the European harvest season for fruit. The entry-price system in the EU consists of a reference price established by the European Commission and an payable levy on the difference between the price of the shipment and the reference price. The levy has a seasonal variation; it is highest in the European harvest time and lowest in the off-season. The system eligibly has little impact on exports to the EU from tropical countries and countries in the southern hemisphere. Using tariff data (including ad valorem equivalent of specific tariffs) from the TRAINS database, accessed via WITS, EU import tariffs are analyzed for selected fruit products for the years 1996-2007. The FTA has substantially brought import tariffs for Chilean fruit down from rates between 10 and 15 percent in the late 1990s to less than 5 percent, e.g. for apples, and to duty-free access, for example for grapes (albeit with quota), cherries and plums.

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[3] The schedule for elimination is described in the annexes of the Association Agreement (http://ec.europa.eu/trade/issues/bilateral/countries/chile/euchlagr_en.htm).

3.2. Heterogeneity of pesticide MRLs

Based on good agricultural practice on the one hand and on consumer intake and risk assessment on the other hand, MRLs define the maximum legal level of concentration for an active substance/pesticide in or on agri-food products. Hence MRLs are not maximum toxicological limits but rather the lowest maximum levels of contaminants, which can be reasonably achieved with good agricultural practices (van der Meulen and van der Velde, 2004). Next to prevalent production methods, research in plant protection measures and other factors, climatic conditions that favor different pests and legitimate the application of pesticides against them crucially determine which pesticides are applied and consequently regulated. Not all pesticides available on the market are equally used in countries. Furthermore, if toxicological concerns are high and/or alternatives protection methods are available pesticides can be entirely prohibited.

Although pesticide MRLs are measured in numerical elements and can thus be ranked on an objective scale, comparing them bears some challenges. First, the list of pesticide/active substances regulated can be very long and also includes those active substances that do not have a major effect on production. Second, different countries do not necessarily regulate the same pesticides, and as mentioned above, separate tolerance levels for imported products may have been established. Similarly, some countries impose bans on the usage of certain pesticides but others do not. In international trade, pesticide bans usually result in zero tolerance if the respective substances are found in imported products, and they are thus obviously most restrictive. Third, pesticide regulations tend to be regularly adjusted to reflect the recent scientific knowledge and detection methods as well as technology advances in production methods (good agricultural practises). These dynamics in regulations make the comparison of pesticide MRLs a complex task. In particular, comparing the requirements over time is often impossible because only information on current MRLs is usually available.

Our case study focuses on the pesticide MRLs for six varieties of fresh fruits in detail: apples, cherries, blueberries, grapes, kiwifruit and plums. These fruit varieties on average account for about 40% of total agri-food exports from Chile to the EU15 and are thus particularly relevant. For each type of fruit, several limits of pesticides/active substances apply and the pesticide combinations differ according to variety. The data on the pesticide MRLs set by the EU is available from an on-line database provided by the EU Commission's Directorate-General of Health and Consumer Protection (see http://ec.europa.eu/sanco _pesticides/public/index.cfm). This EU pesticide database contains the MRLs defined in the annexes of Regulation EC/396/2005 and allows to search for the MRLs of one or several pesticides for a set of products or to display the full list of pesticide MRLs for a given product. A similar database for Chilean pesticide MRLs is not available. The information about pesticide MRLs in Chile comes from the Extent Resolution No. 581/99. Given the date of the resolution, note that the Chilean MRLs are not up-to-date.

Given the available information, table 1 gives an overview on the pesticide MRLs for the selected fruits in Chile and the EU, and the international standards of pesticide MRLs by the Codex Alimentarius are also presented. The table refers to the number of pesticide MRLs rather than the value of MRLs; the detailed list of MRLs is available upon request. As presented, the EU considerably regulates pesticide residues in fresh fruits. For each of the fruit varieties looked at, the EU has set a total of 435 pesticide MRLs, and they include distinct levels according to fruit variety (specific MRLs) as well as levels reflecting the limit of determination (LOD). For those pesticide residues which are present in products/groups of products but for which MRLs are neither provided at the EU-level nor laid down at the national level of the member states, the EU uses default values of the maximum concentration allowed. The default values represent the lowest residue concentration that can be detected (limit of determination) and are generally set at 0.01 mg/kg (Regulation EC/396/2005, Article 18.1b). While being very restrictive, the default values do not necessarily constitute import requirements for foreign plant products. Graffham, A. (2006) provides an overview of import requirements.

On average, about 95 of the total number of EU pesticide MRLs are set according to the LOD, but it is unclear whether the LOD of the respective pesticides is used for health reasons or as a default value when in fact no common EU regulation exists. The number of specific MRLs is particularly high for apples and grapes, respectively amounting to 128 and 133 pesticide residues actually regulated. With regard to Chile and the Codex, the number of pesticide MRLs for apples and grapes is also highest. In comparison to the EU, the number of pesticide MRLs set by Chile and the Codex is much smaller, and this is also the case if only the EU’s specific MRLs are considered. Focusing on specific pesticide MRLs, the EU regulates about 75% more pesticides than Chile and about 60% more than the Codex Alimentarius. Note that the mere number of MRLs does not give information on the stringency. Considering those pesticide residues that are regulated by both the EU and Codex, the values of the EU MRLs are smaller than the corresponding Codex value in most cases, indicating that the pesticide MRLs in the EU tend to be tighter than the Codex MRLs. While Chile usually takes the Codex standards as their own MRLs, the number of pesticide MRLs in Chile is slightly smaller than the number of Codex pesticide MRLs, and in few cases the pesticide residues allowed in Chile are stricter than the corresponding Codex MRLs.

Table 1: Number of pesticide MRLs for selected fresh fruits*, Jan./Feb. 2009.

		Chile	**Codex**	**EU**
Apples	Specific MRLs	48	76	128
	LOD		7	307
	Total	**48**	**83**	**435**
Cherries	Specific MRLs	27	55	102
	LOD		3	333
	Total	**27**	**58**	**435**
Blueberries	Specific MRLs	13	19	61
	LOD		1	374
	Total	**13**	**20**	**435**
Grapes	Specific MRLs	41	66	133
	LOD		2	302
	Total	**41**	**68**	**435**
Kiwifruit	Specific MRLs	15	11	48
	LOD		0	387
	Total	**15**	**11**	**435**
Plums	Specific MRLs	24	35	96
	LOD		3	339
	Total	**24**	**38**	**435**

Source: own illustration.

3.3. Constructing a heterogeneity index for pesticide MRLs

In the literature, heterogeneity indices have been constructed for products other than agri-food products. For example, Nicoletti et al. (2000) measure the relative stringency of standards of manufacturing goods in terms of a summary index. In their study, standard requirements are ranked from 0 to 6 (with 0 for the least stringency and 6 for the highest) and subsequently summed up to construct an index. Kox and Lejour (2005) develop an index for policy heterogeneity in the service sector using a binary approach. If a specific item of regulation differs between countries, they assigned the value 1, and 0 otherwise. The final index is the average value for the total items. This means that if two countries have differences in every item of regulations the value of the index is 1, and when all regulations are equal the index is 0. Kox and Lejour (2005) hence consider that equal requirements between countries do not obstruct trade, and just higher standards requirements in the importer country will act as a barrier. While following Kox and Lejour (2005) by averaging the difference of individual regulation, we adapt their binary approach to a quantitative approach. That is, we construct our index for pesticide MRLs by using the actual difference in MRLs, which are different for each pesticide, instead of assigning the value of 1 if requirements differ. In order to standardise the indicator, the difference in the MRLs is divided by its sum and thus our regulatory heterogeneity indicator aims to reveal relative difference in MRLs, The indicator is calculated as follows:

$$r_n = \frac{MRLn_{\exp} - MRLn_{imp}}{MRLn_{\exp} + MRLn_{imp}} \tag{I}$$

where r_n is the standardized difference in MRLs for pesticide n. $MRLn_{exp}$ and $MRLn_{imp}$ are the maximum residue levels in the exporting and importing country, respectively.

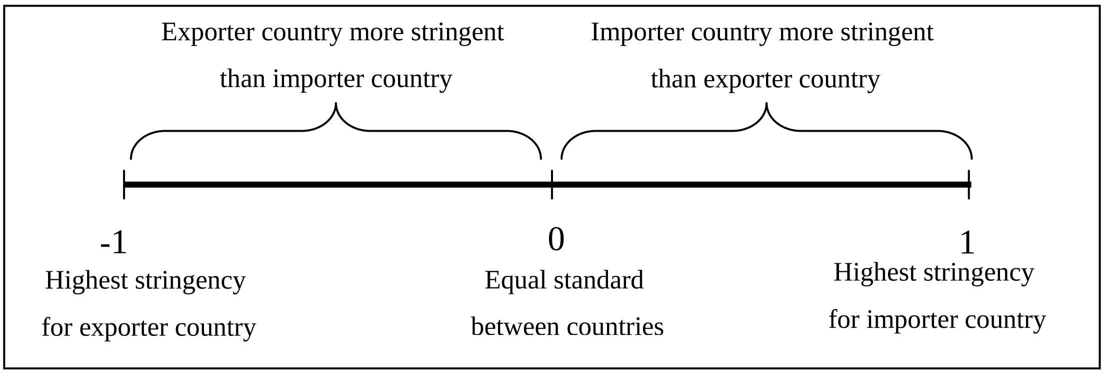
The difference in MRLs is divided by their sum in order to turn the absolute value of the difference in a standard value that lies in the interval [-1, 1]. The extreme values of -1 and 1 indicate that one of the trading partners bans the respective pesticide. For example, if the importer country banned a pesticide (MRL = 0) and if the exporter country set an MRL of 5 mg/kg the indicator r_n would equal 1, indicating that the importer country has the highest level of stringency in that regulation. If the exporter country imposed a ban the resulting indicator would be –1, indicating that the level of stringency is highest in the exporter country. For $r_n > 0$ the regulation of the importer country is more stringent, and for $r_n < 0$ the one of the exporter country is more stringent. When both countries impose the same MRLs, the value of the indicator becomes 0. Values close to 0 generally mean less stringency while values close to $|1|$ mean more stringency.

Figure 1 shows the rage of values of the indicator r_n and their respective interpretation. As highlighted, the stringency indicator for pesticide MRLs has the following properties:

1. The indicator presents a relative value for MRLs of different pesticides and is comparable across among pair of trading partner countries.
2. The indicator can identify which country is more stringent in the regulation. Negatives values imply that the exporter country is more stringent, and positive value indicates that the more stringent country is the importer country. In absolute terms, values close to 0 imply a lower stringency difference between the pairs of trading partners, and values close to 1 imply a higher stringency difference.

3. The indicator covers the case of equal standard of MRL in pairs of importing and exporting countries.
4. The extreme case when one of the trading partner countries banns respective pesticides is covered. If in both countries the pesticide is banned, the indicator can not be estimated since the denominator of the expression will be 0.

Figure 1: Value range of stringency indicator for MRLs.



Source: own illustration.

Many pesticides are regulated in each country, and the final regulatory heterogeneity index I_i for the specific product i is calculated as the average value for all regulated pesticide MRLs by the following formula:

$$I_i = \frac{\sum_{n=1}^{N} r_n}{N} \tag{II}$$

where N refers to the number of pesticides included in the index, and r_n gives the stringency value in the range of [-1, 1] as described above.

We apply the regulatory heterogeneity index for pesticide MRLs imposed on fresh fruit in trade between Chile and the EU. Using available data sources, we calculate the index for the six fruit varieties chosen, whereby Chile is the exporting and the EU15 is the importing country. Note that we use the list of Chilean pesticide MRLs as our starting point. While Chile generally falls back to the Codex standards, considerably less pesticides are regulated in Chile and in cases where both the EU and Chile sets pesticide MRLs the EU levels are usually more stringent.

For each of the six fresh fruits, table 2 presents the index of average differences in pesticide MRLs for Chile and the EU. The indices calculated reflect that the pesticide MRLs in the EU are on average more stringent that in Chile. The differences in the stringency of MRLs has a slightly variation across products. While the highest difference is observed for blueberries (0.74), the difference is lowest for grapes (0.49). As it can be see in table xx, most of the index value are around 0,5. However, note that Chile sets more stringent MRLs for some pesticides. For example, the residue limits of the substance dithiocarbamates, pirimicarb and parathion-methyl are consistently lower in Chile than in the EU standards. Analyzing the information on pesticide MRLs by fruit variety, 4 out of the 27 Chilean MRLs for cherries were tighter than the EU MRLs. The same applies to 4 out of the 69 Codex MRLs for grapes and to 3 out of the 38 Codex MRLs for plums.

Table 2: Index of average differences in pesticide MRLs for selected fruit products required by Chile and EU.

Exported products	**Stringency index ($I_{\text{Chile, EU15}}$)**	**Number of pesticides considered in the index (N)**
Apples	0.55	48
Cherries	0.52	27
Blueberries	0.74	13
Grapes	0.49	41
Kiwifruit	0.53	15
Plums	0.54	24

Source: own calculation.

It is important to mention some of the drawbacks of the estimated index. In the case at hand, only MRLs regulated in both countries were used for the estimation. The EU has a longer list of regulated MRLs than Chile, and thus not all of the EU's pesticide MRLs are reflected. We attempt to capture the most relevant pesticides in our index by focusing on the Chilean regulation assuming are more used. Another main drawback is that we consider all pesticides to be equally important. Although restrictions on pesticide residues do not have the same impact on production, we do not account for specific weights in the calculation of the index. In order to improve the index some kind of ranking the importance of the respective pesticide MRLs would be useful. Since pests and deceases change over time as well as over the areas planted, assigning weights for each pesticide MRL turns out to be a difficult task, and detailed information on the application of pesticide would be necessary. In our case, this could involve surveys on the Chilean producers' pesticide application which is beyond the scope of this report.

4. Application of the index in the empirical analysis

4.1. Estimation model

We use a standard export demand approach to model the impact to the stringency index on the volume of trade (Kenan and Rodrik, 1986; Doyle, 2001). As pointed out by Bahmani-Oskooee et al. (2008), export – import demand functions includes a scale variable and a relative price term. On the other side, new trade models take into account transportation costs and product differentiation as key variables for a good performance of the estimation (Neary, 2009). For the estimation of the Chilean export supply of selected fruit to the EU, we propose the following model:

$$X_{it} = \beta_0 + \beta_1 P_{it} + \beta_2 RGDP_t + \beta_3 TC_t + \beta_4 ER_t + \beta_5 T_{it} + \beta_6 I_{it} + \varepsilon_{it} \quad (1)$$

where X_{it} is the export volume of product i from Chile to the EU15 in period t, $RGDP_t$ is real gross domestic product of the importer used as a proxy of the scale variable, income. P_{it} is the real FOB price of the exported product i, and ER_t is the exchange rate between the importer and exporter country. Both variables are considered as relative price terms. The variable T_{it} represents the tariffs that the importing country imposes on product i in period t, and TC_t is transportation cost, measured in this case as the oil price in period t, since we are only dealing with two countries. The regulatory heterogeneity index is denoted I_{it}. The index included in the model is the one estimated in the previous section. Note that our index is fixed over time because only updated information on MRLs is readily available to calculate the index.

The model presented is a panel data (or pooled data) model, where the regression equation uses both a temporal and a cross-sectional dimension. In our case, the temporal dimension is a period of time of 12 years (1996 to 2007) and the cross sectional dimension is given by the six fresh fruits included in the analysis. For such panel models, two alternative estimation methods are considered: a fixed effect estimation among the groups of observations, in our case among the six fruit products, and a random effect model estimation which implies a particular stochastic term in each group beside the traditional error term. For the case at hand, a random effect model is chosen since we do not expect fixed differences in the Chilean export demand to EU for fresh fruits. Instead, each particular fruit variety can be expected to be subject to specific influences (e.g. nutrition, season, holidays, etc.). The following equation is estimated as a random effect model:

$$X_{it} = \beta_0 + \beta_1 P_{it} + \beta_2 RGDP_t + \beta_3 TC_t + \beta_4 ER_t + \beta_5 T_{it} + \beta_6 I_i + \mu_i + \varepsilon_{it} \tag{2}$$

where μ_i is the random term that is assumed to be normally distributed with $N(0, \sigma^2)$ and uncorrelated with the error term ε_{it}.

Except for the explanatory variables I_i,, equation (2) is transformed into natural logs and estimated for Chile as the exporting country and the EU15 as the importing country. The trade data between Chile and the EU15 are annual time series between 1996 and 2007 (12 years). The panel is constructed using trade variables (volume of trade and unit value) for: blueberries (HS6 code: 081040), kiwifruit (081050), cherries (080920), plums (080940), grapes (080610) and apples (080810). Table A2 in the appendix gives the detailed summary description of the variables in the model and the corresponding data sources used.

The model was estimated in the software NLogit 4.0.

4.2. Estimation results and discussion

Looking at the data set reveals that some of the explanatory variables included in the model are highly correlated, and therefore would cause co-linearity problems in the model. Table 3A in the appendix presents the correlation coefficients. As shown, the real GDP, the exchange rate and the oil price are particularly high correlated and we therefore decided to eliminate two of the three variables for the estimation.

In order to decide on the variables to incorporate in the model, we estimate the full model and check the significance of each of the three variables. Since the exchange rate (*ER*) has the highest level of significance, we incorporate it in the final model, while leaving the other variables out. Table 3 presents the results of the corresponding estimation.

According to the results, the estimated model has a good performance and most of the variables are significant in the model. The R^2 is 0.82 and thus indicates that the model fits well. According to the Lagrange Multiplier Test, the random effect model is preferred to the fix effect model.

Table 3: Estimation results of the EU15 import demand model for selected Chilean fresh fruits, random effect model estimation.

Variable	Coefficient	Estimated Coefficient	t- value	$P(t > t_c)$
Constant	β_0	5.58**	2.09	0.04
$\ln P_{it}$	β_1	-0.80***	-3.07	0.002
$\ln ER_t$	β_4	1.87***	5.87	<0.0001
T_{it}	β_5	-0.008	-0.14	0.88
I_i	β_6	-14.84***	-4.5	<0.0001
$R^2 = 0.82$				

*significant at 10% confidence, **significant at 5%, ***significant at 1%.

Source: own estimation.

The coefficient associated to the product price (*LnP*) is highly significant and has a negative sign, as expected. A price increase reduces export demand. Since the variables are expressed in natural logarithm the interpretation of the coefficient is the price elasticity measure, and we can state that a 10% increase in the price implies a decrease in the trade volume by 8%. The effect of the exchange rate is positive, significant and highly elastic. The value of the coefficient indicates that a 10% increase of the real exchange rate between Peso and Euro leads to a 18,7% increase in the trade volume. As expected, the estimated coefficient of the exchange rate indicates that a depreciation of the Peso against the Euro reduces the landing price of Chilean fruit in the EU, thereby resulting in increased exports from Chile. The coefficient shows that the exchange rate is more sensitive than the price, meaning that the exchange rate has a higher impact on the exporters' returns than price. While having the expected sign, the tariff reduction coefficient is not significant.

The regulatory heterogeneity index variable (*I*) returned significant and with the expected negative sign on the coefficient. If MRLs in the EU are more stringent than the corresponding MRLs in Chile the index is positive and the impact on exported volume is negative. To understand the magnitude of the impact of the regulatory heterogeneity index we use the index elasticity that is reported for each of the six fruits in table 4. As shown, exports are highly sensitive to changes in the index and there are only minor differences in elasticities across the different fruit types.

Table 4. Elasticity of exports to the index value for selected Chilean fresh fruits exported to EU(15).

Type of fruit	Index elasticity	Estimated impact on trade volume, 5% increase of the stringency index
Apples	8.16	40.8%
Cherries	7.72	38.6%
Blueberries	10.98	54.9%
Grapes	7.27	36.4%
Kiwifruit	7.87	39.3%
Plums	8.01	40.1%

Source: own calculation

Obviously, the sensitivity of exports to changes in the underlying MRL regulations is most interesting. An example is useful here. Let us assume that the EU reduces the regulatory tolerance level for each of the 48 MRLs in apples trade by 5%. Under this scenario the regulatory heterogeneity index takes the value of 0,56, an increase of

1,8% (see table 5) Multiplied by the elasticity of apple exports to a change in the index, this results in a decrease of the export volume by 14.8%. We observe no differences in export volume across products to a change in MRLs, with the exception of grapes that are twice as sensitive than the other products.

Table 5: Simulation of the trade impact following a 5% decrease of the regulatory tolerance level for EU MRLs.

Type of fruit	Index after 5% reduction in all MRLs	% change in index	% change in trade volume
Apples	0.56	1.8%	-14.8%
Cherries	0.53	1.9%	-14.8%
Blueberries	0.75	1.4%	-14.8%
Grapes	0.51	4.1%	-29.7%
Kiwifruit	0.54	1.9%	-14.8%
Plums	0.55	1.9%	-14.8%

Source: own calculation

The first thing that raises the attention regarding the expected impact of the regulatory heterogeneity index is the high value of the elasticity and therefore its impact on trade volume. However, it needs to be noticed that as the index is composed by many different pesticides is not very sensitive in value. As the example shows, if all pesticide MRLs were increased by 5% trade of most of the fruits would change by around 15%.

5. Conclusion

An assessment of the trade impact of SPS requirements is first and foremost an empirical issue, and we argue that the relative differences of SPS regulations trigger the impact on trade flows between trading partner countries. In this paper we have identified the scope of possible regulatory differences that may affect agri-food trade, and found that it is a considerable challenge to bring this scope into a quantification framework. In order to capture the relative differences, we apply an index of regulatory heterogeneity for the case study of trade in selected fruit products between Chile and the EU.

Existing approaches designed to incorporate a regulatory comparison in trade into a quantification framework appeared unsatisfactory in particular with regard to the use of binary data on standards and regulations. A simple yet innovative indicator designed for the purpose of comparison regulations on MRLs was more satisfying in that respect because it summarized two relevant types of information: the relative differences in regulation and the information on the most stringent trade partner. In comparison to the existing indices of policy heterogeneity, however, the depth of information generated by our index severely compromised its coverage. Future work will need to address greater coverage, in particular with regard to market approval requirements, process standards and conformity assessment procedures.

While our heterogeneity index improves on the current state of the art in quantifying the trade impact of SPS regulations, the obtained insights about the distinct impact of regulatory requirements are particularly useful in the light of cooperation on standards within trade agreements, such as the EU-Chile Association Agreement that aims at reducing possible trade impediments due to differences in SPS regulations.

6. References

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Table A1: Categories of SPS requirements.

Product standards	
Labeling	Labeling is any written, electronic, or graphic communication on the consumer packaging or on a separate but associated label.
Marketing	Measures defining the information that the transport/distribution packaging of goods should carry, which are directly related to food safety.
Packaging	Measures regulating the mode in which goods must or cannot be packed and defining the packaging materials to be used, which is directly related to food safety.
Maximum levels of residues, contaminants and other ingredients	Maximum concentration level of residue and other substances (MRLs) permitted, which enter the product during the production and/or distribution processes, or restriction on the use of certain substances as ingredients
Process standards	
General hygienic requirements	Restrictions to avoid the contamination by microorganisms/parasites in foods/feeds that cover production, manufacturing, transport and storage conditions.
Process regulation for plant production	e.g. post-harvest treatment and pathogen controls
Process regulations for animal production	e.g. food safety and quality management, including the requirement to inform about the processing history at all stages of animal production
Conformity assessment requirements	
Certification	Certification issued by governmental agencies or third parties either in the importing or exporting country; possible requirement of translating certificates in the language of the importing country.
Testing requirements	Sampling requirements usually associated with testing or laboratory fees, both in the exporting country or at customs
Inspection requirements	Inspection of products either by public or private entities, including border inspection
Registration requirements	Importers may need to be registered in the importing country (pre-listing) or exporters may need to contact a registered importer.
Quarantine requirements	Quarantine for imports during a certain period.

Source: own illustration based on new TRAINS classification (available under http://ntb.unctad.org/about.aspx).

Table A2: Model variables and data sources.

Variable	Description	Source
X_{it}	Export volume for each fruit product, measured in tons per year.	Trade database by the Chilean Studies and Agrarian Policies Bureau
P_{it}	Real unit value at FOB prices of traded products in dollars per ton. It is calculated as total exported value in current dollars divided by exported volume. This result is transformed in real terms using Chilean CPI.	Total export value: trade database of the Chilean Studies and Agrarian Policies Bureau Chilean CPI: Central Bank of Chile
$RGDP_t$	Real gross domestic product for EU. The nominal GDP is deflated using the EU consumer price index (CPI).	Annual GDP in current prices and CPI: Eurostat.
TC_t	Real oil prices in dollar per barrel. The current prices are transformed into real prices using Chilean CPI.	Statistical database of the Energy Information Administration. (http://tonto.eia.doe.gov/dnav/pet/hist/wtotworldw.htm)
ER_t	Real exchange rate between Chile and the EU calculated by using the respective dollar exchange rates for Chile and the EU. The ratio of exchange rates is transformed in real terms by using the corresponding consumer price indices as follows: $ER = \frac{ER_{Ch}}{ER_{EU}} \cdot \frac{CPI_{EU}}{CPI_{Ch}}$	The real exchange rate for Chile (ER_{Ch}) is obtained from the Central Bank of Chile, and the real exchange rate for the EU (ER_{EU}) is obtained from the Federal Reserve database: (www.federalreserve.gov/Releases/)
T_{it}	Annual trade-weighted import tariff applied to each fruit including ad valorem equivalents of specific tariffs. The weights are computed from HS8 digit import values in the Eurostat/COMEXT database	Tariff information was generated for multiple years from the Trade Related Information System (TRAINS) of the UN Conference on Trade and Development, accessed via the World Integrated Trade Solution (WITS)
I_i	Regulatory heterogeneity index for pesticide MRLs	Calculated as described in 3.2.

Table 3A: Correlation coefficients among explanatory variables.

	P	*RGDP*	*TC*	*ER*	*T*	*F*
P	1	-0.11	-0.09	-0.10	0.08	-0.51
RGDP		1	0.77	0.87	-0.29	0.00
TC			1	0.63	-0.36	0.00
ER				1	-0.19	0.00
T					1	0.17
F						1

Source: own estimation.