"Comparing apples with pears". How differences in pesticide residues regulations impact trade?

Sophie S. Drogue, Federica Demaria

WORKING-PAPER – UMR MOISA

"Comparing apples with pears". How differences in pesticide residues regulations impact trade?

Drogué, S. ; DeMaria, F.

WORKING PAPER MOISA 2012-1

WORKING-PAPER – UMR MOISA

"Comparing apples with pears" How differences in pesticide residues regulations impact trade?

Sophie Drogué[1] **; DeMaria, Federica**[2]

[1] INRA, UMR 1110 MOISA, F-34000 Montpellier, France
[2]University of Calabria, Department of Economics and Statistics, Rende, Italy

Janvier 2012

Abstract
The impact of food safety standards on international trade has already been addressed. Generally, economists try to assess trade losses borne by exporters when importing countries impose stricter regulations. In this paper we assess the impact of the Maximum Residue Levels (MRL) of pesticides on the trade of apples and pears. Rather than focusing on a particular pesticide we take into account the entire list of substances set out by the various regulations with the aim of understanding how the similarity (or dissimilarity) of these can affect trade. Most studies assess the impact of sanitary standard regulations introducing directly in the analysis the MLR put in force in the importing country. We assume that what can be crucial is the difference in the tolerance levels of both the importing and exporting country. Having built a similarity index we then introduce it into a gravity equation to assess the impact of differences in MRL of pesticides on the trade of apples and pears of seven exporting and seven importing countries. Results suggest that harmonizing regulations impacts trade differently depending on the exporter.

Keywords : Food safety, Standards, Pesticides, MRL, Apple, Pear, Market access

Résumé
L'impact sur le commerce international des standards de sécurité alimentaire a souvent éte étudié. Généralement les économistes essaient d'évaluer les pertes supportées par les exportateurs quand les pays importateurs imposent des réglementations plus strictes. Dans cet article, nous évaluons l'impact des Limites Maximales de Résidus (LMR) de pesticides sur le commerce de pommes et de poires. Plutôt que de se focaliser sur un pesticide en particulier, nous prenons en considération la liste complète des substances établies par les diverses réglementations avec pour but de comprendre comment les similarités (ou différences) entre elles affectent le commerce. La plupart des études évaluent l'impact des réglementations sanitaires en introduisant directement dans l'analyse le LMR en vigueur dans le pays importateur. Nous faisons l'hypothèse que ce qui importe c'est plutôt la différence entre les niveaux de tolérance du pays exportateur et importateur. Après avoir construit un indice de similarité, nous l'introduisons dans une équation de gravité pour évaluer l'impact sur le commerce de pommes et poires des différences entre niveaux acceptables de résidus de pesticides pour sept pays exportateurs et sept pays importateurs. Les résultats suggèrent qu'harmoniser les réglementations aurait un impact différent selon le pays exportateur.

Mots-clés : Sécurité alimentaire, Standards, Pesticides, LMR, Pomme, Poire, Accès au marché

JEL: Q13, F13

Communication présentée au 13ème congrès de l'EAAE, Zurich (CHE), 30/08-02/09/2011

1 Introduction

Previous research has already addressed how food safety standards affect international trade (Henson and Mitullah, 2000; Otsuki and al., 2001a and 2001b; Wilson and Otsuki, 2003; Wilson and Otsuki, 2004; Moenius 2006). Generally, economists try to assess trade losses borne by exporters when importing countries impose stricter regulations. Standards affect trade competitiveness insofar as they imply a cost of compliance on producers which increases the price of a product. Furthermore it is a commonly accepted result in the literature that standards are trade-impeding; at least for agfood trade from developing countries. However there are some studies that highlight a positive impact on trade. Moenius (2006) has sought to show a positive impact of exporters standards on agfood trade as they *can establish trust and reduce search costs for consumers*. Disdier and al. (2008) report the *dual effects of SPS and TBTs in agriculture* which *can have no impact on trade or even facilitate it as they carry information and confidence on the imported products.* Following Li and Beghin (2010), *the literature shows a wide range of estimated effects from significantly impeding trade to significantly promoting it.* Henson and Jaffee (2008) argue that exporters facing strict food safety standards incur a cost of compliance which may be *offset by an array of benefits from the enhancement of food management capacity*.

Departing from this argument, we assess the impact of the Maximum Residue Levels (MRL) of pesticides on the trade of apples and pears. *The MRL is an index which represents the maximum concentration of a pesticide residue (expressed as mg/kg) legally permitted in food commodities and animal feeds. MRL on food imports are set by each country and are imposed as regulatory standards at the border* Wilson and Otsuki (2004). We consider that apples and pears are a good case-study as these fruits are affected by numerous phytosanitary treatments and are also among the most traded fruits in the world along with oranges. The objective is to compare the "closeness" of standards. We seek to understand how the similarity (or dissimilarity) in regulations can affect trade. Indeed, most studies examine the regulations put in force in the importing country. We assume that what can be crucial is the difference in the tolerance levels of both the importing and exporting country. A country which imposes already strict domestic tolerance levels on pesticides residues may have fewer difficulties in complying with the requisites of a stringent importer given that its producers have already coped with the cost of compliance of maintaining low residue levels.

Unlike other studies we do not introduce a single substance into the analysis but take into account the entire list of pesticides which appear in the various regulations. Moreover the level of the standard set by the importer is not taken into consideration but rather the differences between the importer and the exporter standards. This is done using a similarity index. A similarity index has already been used in the literature to compare regulations on Genetically Modified Organisms (GMO) (Vigani et al., 2010) or varieties of grapes and wines (Anderson 2009 and 2010). In all cases the methodology is adapted from Jaffe (1986). We use the distance associated to the Pearson's correlation coefficient to measure the proximity between regulations then we introduce this index into a gravity model. We assess the bilateral impact of MRL of pesticides for seven exporters (Argentina, Brazil, Chile, China, the EU, New Zealand and South Africa) and seven importers (Australia, Canada Japan, Korea, Mexico, Russia, The US) of fresh and processed[1] apples and pears. These countries have been chosen on the basis of four non excluding criteria (i) their share in the international trade of apples and pears; (ii) the level of their consumption of these fruits; (iii) their presumed stringency in regulations; (iv) the availability of data on their MRL of pesticides.

The paper is organised as follows. Section 2 presents an overview of the MRL regulations in force in importing and exporting countries and details the construction of the similarity index. Section 3 deals with the econometric model and data and presents the results. Section 4 concludes.

2 Maximum Residues Levels of pesticides: an unharmonized frame

Pesticide is a generic term which includes all substances used to avoid or control pests. The Food and Agriculture Organization defines it as: *"any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent*

[1] Dried apples, apple juice and preserved pears.

for thinning fruit or preventing the premature fall of fruit, and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport."

Furthermore pesticides are often hazardous substances that cause harmful or deleterious effects on human or animal and plant health through exposure or dietary intake as they tend to stay in the products in which they have been sprayed even when they are peeled or washed. In order to safeguard consumer health and to promote good agricultural practices, maximum levels of residues of pesticides have been set worldwide. Public authorities regulate these levels based on scientific prediction of an acceptable daily intake (ADI) of residue. When the science is not able to derive an ADI some countries decide to set their MLR at a very low default level on the basis of the precautionnary principle.

International harmonization of MRL does not exist at a global level. Even though the Codex Alimentarius has fixed levels, they are not statutory. National authorities hold the sovereignty in fixing these limits. Therefore these legal limits can vary widely from one country to another. Regarding pesticides residues, there are as many regulations as countries. The number of pesticides registered and the MRL set vary greatly from one country to another. Some have adopted very severe rules with MRL well below the Codex settings and zero-tolerance provisions for disallowed or prohibited substances or for which a MRL cannot be established due to the lack of toxicological data. This is the case of the Russian Federation which was the target of complaints for the stringency of its standards. Whereas other countries have decided to adopt international standards set up by the Codex. This is for example the case in Argentina, Brazil, Chile, Korea, New Zealand or South Africa. Another important difference is the list of substances registered in regulations. These provisions are summarized in table 1. Some countries (eg. the US or the EU) have a very detailed list while others provide a limited number of pesticides but zero tolerance provisions or a very low tolerance level for those which are not registered (as in Australia, Canada or Mexico). Other countries have more complicated system. For example, Korea imposes 236 limits for apples and 210 for pears. If a limit is not set for a product, the Codex standard shall apply, otherwise the limit for the most similar product applies. If none of these solutions are applicable, the lowest limit for MRL of pesticides shall apply (equal to 0.01 mg/kg). New Zealand has 112 limits for apples and 107 for pears. Codex MRL are recognised for imported food, Australian MRL recognised for food imported from Australia. If no MRL exists, a default MRL of 0.1 mg/kg applies. In Russia limits are set for 124 pesticides for apples and 122 for pears. In 2008 Russia signed two bilateral memorandums with the EU and Chile. They stipulate that '*if there is no Maximum Residue Level for pesticide residues, nitrates and nitrites specified for a certain type of product in the Russian legislation, the MRL for the most similar product included in the same commodity group (as defined in the Codex Alimentarius) applies, and that if there is no MRL for the commodity group, the MRL of the Codex Alimentarius applies. If there is no MRL of the Codex Alimentarius, the MRL of the country of origin applies*'.

Table 1: Number of pesticides registered in countries' regulations

	Nb. of pesticides registered for apples	**Nb. of pesticides registered for pears**	**Rule when a pesticide is not registered**
Argentina	108	92	1- Codex 2- Zero-tolerance
Australia	175	160	Zero-tolerance
Brazil	175	12	Codex
Canada	93	83	Default limit of 0.1 mg/kg
Chile	103	91	Codex
China	57	66	?
EU	526	526	Default limit of 0.01 mg/kg
Japan	391	767	Default limit of 0.01 mg/kg
Korea	236	210	1- Codex 2- Limit of most similar group of product 3- Default limit of 0.01 mg/kg
Mexico	72	105	Zero-tolerance
New Zealand	112	107	1- Codex recognised for imported food 2- Australian MRLs recognised for food imported from Australia. 3- Default limit of 0.1 mg/kg applies
Russia	124	122	1- Codex 2- Memorandum with Chile and the EU 3- MRL of the most similar product 4- MRL of the country of origin
South Africa	130	107	Codex
USA	799	799	Zero-tolerance

Source: Homologa and national regulations

The issue of non harmonization of food safety regulation and its possible impact on trade has already been questioned. Wilson and Otsuki (2003) have estimated that adopting the Codex standard on Aflatoxin B1 would raise world cereal and nut exports up by US$ 38.8 millions. Wilson and Otsuki (2004) assessed the impact on trade of harmonizing the MRL of chlorpyrifos on banana trade between 21 exporting countries and 11 OECD importing countries. They found that increasing the stringency of the MLR of this pesticide would have a negative impact on trade.

We investigate the influence of MRL of pesticides on trade flows between seven importers and seven exporters of fresh and processed apples and pears. Countries in the sample have been chosen on the basis of four non exclusive criteria (i) their share in the international trade of apples and pears; (ii) the level of their consumption of these fruits; (iii) their presumed stringency in regulations; (iv) the availability of data on the MRL of pesticides they have set. The impact of the non harmonisation in regulation and how it affect trade of these two fruits is also assessed. We assume that concerning MRL, the main point is the similarity between regulations more than the absolute level of stringency and presume that producers operating in a country which already impose stringent standards would have fewer difficulties in complying with stringent import standards.

We use a direct measure of standards to compute an index measuring the (dis)similarity in regulations, and assume that similar regulations enhance trade while different regulations impede trade. An index is then built based on the MRL of pesticides set by each country on apples and pears to assess the impact of these regulations on trade. The main difference from previous studies (Otsuki et al. 2001; Wilson et al. 2003; Wilson and Otsuki 2004 or Xion and Beghin 2010) is that we compute our index based on all pesticides found in those regulations rather than just one or two main substances. In the literature the similarity index has been used by Anderson (2009, 2010) or Vigani et al. (2010). Anderson (2009 and 2010) uses varietal-based Regional Similarity Index adapted from the Jaffe (1986) methodology to investigate the regional "closeness" of grapes and wine in Australia and in the world. Vigani et al. (2010) use the same methodology to investigate how the similarity or dissimilarity in GMO regulation affects bilateral trade. Their study show that countries with strong differences in GMO regulations trade less suggesting that an international harmonization is needed. We do not use the Jaffe's index but instead compute the distance associated to the Pearson's coefficient correlation.

SIM_{ij}^{k} is the Pearson distance and it is computed as :

$$SIM_{ij}^{k} = 1-(\frac{1}{n}\sum_{p=1}^{n}(\frac{x_{ip}^{k}-\overline{x}_{i}^{k}}{\sigma_{i}^{k}})(\frac{x_{jp}^{k}-\overline{x}_{j}^{k}}{\sigma_{j}^{k}}))$$

Where n is the number of pesticides registered, x_{ip}^{k} is the MRL of the exporting country i for pesticide p and product k .

The Pearson's correlation coefficient lies in the range [-1,1], the corresponding distance falls between [0,2]. A value of SIM equal to 0 means that the two compared samples are similar.

Something must be said on the building of the MRL database from which we derived our SIM index. As pointed out in the first section, regulations are very dissimilar between countries and n is different from one country to another. We choose to introduce into the index all the pesticides found in the regulations analysed. A total of n = 749 pesticides are registered. But if some pesticides are common to all regulations, it is not the case for all. Then when a pesticide does not appear in a country list, the default value applies. In the case that no default value is available we consider the pesticide as authorized by the national regulation and arbitrarily attribute it a value of 75 (the maximum value found in all regulations).

Table 2: Values of the index of similarity *SIM* for apples

	Argentina	Brazil	Chile	China	EU	New Zealand	South Africa
Australia	0.61	1.21	1.22	1.08	0.93	0.71	1.20
Canada	0.79	1.16	1.18	1.02	0.91	0.82	1.15
Japan	0.88	1.23	1.13	1.04	0.29	0.75	1.11
Korea	0.53	1.27	1.23	1.04	0.61	0.50	1.16
Mexico	0.87	0.99	0.99	0.99	0.81	0.97	1.00
Russia	0.17	1.30	1.36	1.00	0.81	0.48	1.24
USA	0.71	1.16	1.16	1.05	0.88	0.77	1.13

Source: Author's own calculations from HOMOLOGA database

Table 3: Values of the index of similarity *SIM* for pears

	Argentina	Brazil	Chile	China	EU	New Zealand	South Africa
Australia	0.48	1.25	1.25	1.09	0.95	0.93	1.22
Canada	0.88	1.14	1.15	1.05	0.93	1.01	1.14
Japan	0.67	1.22	1.20	1.09	0.41	0.98	1.17
Korea	0.49	1.28	1.25	1.07	0.89	0.94	1.18
Mexico	0.92	0.97	0.97	0.99	0.86	0.79	0.99
Russia	0.16	1.35	1.36	1.01	0.84	0.93	1.25
USA	0.68	1.16	1.15	1.09	0.97	0.98	1.14

Source: Author's own calculations from HOMOLOGA database

Values of the index of similarity are reported in tables 2 and 3 and represented in figures A.1 and A.2 in appendix A. These two tables show clear differences between exporters. Argentina, the EU and New Zealand display index of similarity lower than 1 indicating high "correlation" with the regulation of their partners, while Brazil, Chile, China and South Africa displays values greater than 1 which can indicate a lower level of similarity. Referring to table 1 it is interesting to notice that Brazil, Chile and South Africa apply the value of the Codex as default value.

3 Model specification and data

In order to assess the impact of pesticides residues standards on trade of apples and pears, we use a gravity model. Apples and pears are a particularly good case-study as these fruits are greatly affected by contaminants such as pesticides because of the numerous phytosanitary treatments they are subject to and because these substances tend to stay in products even when they are peeled or washed. Moreover, they are products of the temperated zone involving countries both from developed and developing areas. They are the most-highly consumed fruits (along with oranges) in the US and the EU. They are easily shipped and represent important levels of trade both in value and volume. On the global apple market few players are involved (See tables A.1 to A.4 in appendix). China, the EU, Chile and the USA capture the lion's share of 75 percent of the apples world exports. In 2009 China was the first world provider of apples with 1 million tons of fresh apples sold followed by the EU. Concerning the import side, the EU and Russia distinguish themselves as they represent almost half of the total imports of apples. In 2009 the first apple trade partner of the EU27 was the Federation of Russia. The same actors are involved in the trade of pears.

The use of a gravity equation allows us to avoid imposing pre-established hypotheses on the direction of trade and to use econometric techniques. Gravity modeling has already been widely used to estimate the effect of regulations on hazardous substances on trade. For example, Wilson and Otsuki (2004) use gravity modeling to assess the impact of regulations on MRL of pesticides of 11 OECD countries on banana trade from 21 developing countries. They include in their equation a direct measure of the food safety standard using the level of the MRL of the hazardous substance imposed by the importing country. We assume here that the absolute level does not matter. But what is important is the relative level between the exporting and importing country. If a country imposes stringent rules on its producers they will bear a cost in order to comply with these rules. This cost will certainly affect their price-competitiveness but at the same time they will be more capable of accessing a country which also imposes tight rules. This argument has been supported by Harris and al. (2002) who have evidenced that stringent environmental regulations do not have a significant impact on trade.

Our basic model has the following specification:

$$\ln(X_{ijt}^{k}) = \beta_0 + \beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(POP_{it}) + \beta_4 \ln(POP_{jt}) + \beta_5 \ln(Dist_{ij})$$
$$+\beta_6 \ln(SIM_{ij}^{k}) + \beta_7 \ln(Tarif_{ijt}^{k}) + \beta_8 Transp_{ijt} + \beta_9 Lang_{ij} + \beta_{10} Border_{ij} + \varepsilon_{ijt}^{k}$$

Where i stands for exporter, j for importer, k for product and t for the time. The time period covered by our estimation starts from the year 2000 and ends in 2008. In our model k is defined at the 6 digit-level of the 1996 harmonized system. This level of deseggregation does not cause too much of a problem as apples and pears are homogeneous products and are defined at this level (080810 for apples and 080820 for pears). It is not exactly the same for the processed product and that is the reason why we limit the analysis to dried apples (081330), apple juice (200970) and preserved pears (200840). Importing countries are Australia, Canada, Republic of Korea, Japan, Mexico, Russian Federation and USA, while EU27, Argentina, Brazil, Chile, China, Mexico, New Zealand, South Africa are the exporting countries.

X_{ijt}^{k} is the yearly exportation of product k from country i to country j. Data are obtained from the United Nations database on trade (COMTRADE). They are in US dollar.

GDP_{it} and GDP_{jt} are the real Gross Domestic Products (in 2000 constant US dollars). GDPs measure the potential import demand and export supply of country i and country j, hence the coefficients of β_1 and β_2 are expected to be positive. GDPs come from the World Development indicators (WDI) of the World Bank (WB).

POP_{it} and POP_{jt} are the number of inhabitants of country i and country j in year t. These datasets are from the WDI of the WB. They measure the respective size of the country and the sign of β_3 and β_4 is not *a priori* defined (Oguledo and Macphee, 1994).

$Dist_{ij}$ is the distance between the capitals of country i and country j. This variable is a proxy of the trade cost and β_5 is expected to be negative. Distances come from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII)

SIM_{ij}^{k} measures the (dis)similarity between regulations on pesticides residues in force in country i and country j for product k. This regressor is time invariant $SIM_{ijt}^{k} = SIM_{ij}^{k}$ for all t because the values of MRL do not change over the whole period. The sign of β_6 is expected to be negative because the lower SIM_{ij}^{k} the higher the similarity between country i and country j regulations.

$Tarif_{ij}^{k}$ is the applied ad-valorem customs tariff impose by country j on imports from country i. β_7 is expected to be negative. Data come from CEPII's MacMAps database, national regulations and World Trade Organisation.

$Transp_{ijt}$ is an index measuring the difference between country i and j 's degree of transparency and corruption. Nothing can be said *a priori* on the sign of β_8. This variable is introduced because it influences the respect of the rules and can increase or decrease the Data come from www.transparency.org

$Lang_{ij}$ and $Border_{ij}$ are dummy variables equal to 1 if i and j share a common language and 0 otherwise and to 1 if i and j share a common border and 0 otherwise, respectively. Sharing a common language means that there are some cultural links between countries which is favorable to trade, hence the sign of the corresponding coefficient β_9 should be positive. Sharing a common border is also expected to have a positive impact on trade since border countries are expected to trade more and β_{10} should be positive.

Finally, ε_{ijt}^{k} is the error term that is assumed to be normally distributed with zero mean.

Our sample has 5525 observations, 1867 are non zero observations and 3658 are zero observations, some of these zero maybe due to rounding errors or incompleteness of COMTRADE data, but others may reflect the absence of trade between importing and exporting countries.

3 Estimation results

The simplest way to estimate a gravity equation is by Ordinary Least Squares (OLS). But OLS suffer from a lot of econometric issues. Among them, the log-linearization of the variables can lead to biased estimations in presence of heteroskedasticity as showed by Santos Silva and Tenreyro (2006). They suggest to use it instead of the Poisson Pseudo Maximum Likelihood (PPML) method. PPML can help dealing with heteroskedasticity but assumes that the dependent variable is equidispersed and then fails in presence of overdispersion (i.e. when the variance of occurences exceeds their mean). This issue can be resolved using the Negative Binomial Regression (NBR) where the unobserved heterogeneity among observations is included in the conditional mean by adding a dispersion parameter in the specification of the variance.

The third issue is that of the presence of too many zeros. PPML and NBR assume that all pairs of countries have a positive probability of trading (Burger et al. 2009). But the presence of zero may come either from roundings or from what is called self-selection (Xiong and Beghin, 2010). Self-selection occurs when the complete lack of trade between country pairs is due to a lack of resources or to distances, differences in specialization, seasonality, etc. To overcome this issue, zero-inflated models (ZIM) may help. These models allow the zero to be produced by two different process. They consider the existence of two latent groups. The first one has strictly zero counts while the second has a non zero probability of counts different from zero. Zero-inflated models are two-step models. The first step uses a binary model and the second step a count model. The binary model can be estimated using either a probit or a logit while PPML or NBR can be used for the count model (including zero).

The specification of the ZIP model is:

$$Pr(X_{ijt}^{k} = x \mid z_{ijt}^{k}) = \begin{cases} \Phi(z_{ijt}^{k}\gamma^{k}) + (1-\Phi(z_{ijt}^{k}\gamma^{k}))exp(-exp(z_{ijt}^{k}\beta^{k})) \\ \end{cases}$$

x =0 $\dfrac{(1-\Phi(z_{ijt}^{k}\gamma^{k}))exp(-exp(z_{ijt}^{k}\beta^{k})exp(z_{ijt}^{k}\beta^{k}X))}{x!}$ if x >0 Where $\Phi(z_{ijt}^{k})$ is the probability of zero trade flows due to exporters' self-selection behaviour, $exp(-exp(z_{ijt}^{k}\beta^{k}))$ is the probability of drawing a zero from a Poisson process with parameter $exp(z_{ijt}^{k}\beta^{k})$.

The specification of the ZINB is:

$$Pr(X_{ijt}^{k} = x \mid z_{ijt}^{k}) = \begin{cases} \Phi(z_{ijt}^{k}\gamma^{k}) + (1-\Phi(\frac{\alpha^{-1}}{\alpha^{-1}+exp(z_{ijt}^{k}\beta^{k})})^{\alpha^{-1}} \\ \end{cases}$$

$$\text{x=0}\; (1-\Phi)\frac{\Gamma(X_{ijt}^{k}+\alpha^{-1})}{X_{ijt}^{k}!\Gamma(\alpha^{-1})}(\frac{\alpha^{-1}}{\alpha^{-1}+exp(z_{ijt}^{k}\beta^{k})})^{\alpha^{-1}}(\frac{exp(z_{ijt}^{k}\beta^{k})}{\alpha^{-1}+exp(z_{ijt}^{k}\beta^{k})})^{x_{ijt}^{k}} \text{ if x >0}$$

Two statistic tests allow us to choose between various methods of estimation. First, the value of the Reset test is always greater in the case of the NBR and ZINB compared to OLS and PPML. The Vuong test allows us to discriminate against the use of zero-inflated models searching for significant evidence of excessive zero counts. A Vuong test significantly positive supports the use of zero-inflated models. We then focus on the estimations performed using the negative binomial regression and its zero inflated counterpart on pooled data. The specification includes country pairs fixed effects and time fixed effects to control for time and country variations. Results are reported in Table 4. Results from NBR estimation are in column 1 while results from ZINB are in column 2, the two sets of estimates are highly similar and lead to the same conclusions.

As the model is in log-linear form, coefficient estimates can be considered as elasticities. The coefficients of the GDP are positive and significant for both exporting and importing countries. The size of the population impacts trade positively for exporters and negatively for importers. As expected, the coefficients of the distance and tariff are negative in all regressions even if not always significant. Those of common border and common language are positive. The coefficient of the transparency index is not always significant but negative in all regressions what could suggest a negative impact on trade. Finally, focusing on the variable of interest, we find in all estimations that the coefficient SIM is negative and strongly significant. This means that increasing the similarity (reducing the distance) in regulations would have a positive impact on the trade of apples and pears.

We have then redone the estimations of our model replacing the SIM index with an interaction term between the exporting country fixed effect and the SIM variable, and have then 7 new variables corresponding to the 7 exporting countries. This leads to another picture. Results show that this interaction term is negative and significant for Chile and South Africa, negative but not significant for Brazil. These countries are also those which have an index of similarity greater than 1 with almost all importers. A reduction of the distance between them and their partners would mean more trade as a reputation effect. The cases of Argentina and China are completely different. Even if they have indexes of similarity lower than or equal to one, their coefficients are positive and significant. This suggests that increasing the similarity in regulations with the importers under scrutiny can result in trade diverting. Increasing the strictness of their standards could imply a higher effort of adaptation from producers in these countries to comply with stricter domestic rules increasing the cost of the product and decreasing their competitiveness. For the EU25 and New Zealand, the high income countries of the sample, the results are rather expected, the coefficient is negative but not significant. This suggests that the standards imposed by any exporter do not represent a barrier for those countries which impose already strict rules on their domestic market.

In order to test the robustness of our analysis we replicate all the estimations using very different methods (OLS, PPML, Zero-inflated Poisson model and Hurdel Double Model). The standard gravity covariates have the expected signs, distance is negative and significant, tariff is negative and significant, language and border dummies have a positive sign. Focusing on our variable of interest, in all estimations the coefficient of SIM is negative and significant, meaning that reducing the distance between MRL regulations is trade-enhancing. As a further robustness check we run the gravity equation year by year and the results are still confirmed. Finally, we replicate all the estimations with the Heckman two step procedure. The results are also confirmed. These are not reported but are available on request.

Table 4 : Estimations on pooled data

	NBREG	ZINB	NBREG	ZINB
	1	2	3	4
GDP importer	9.316***	8.091***	8.734***	8.031***
	[1.998]	[1.176]	[1.875]	[0.810]
GDP exporter	4.175***	3.643***	3.851***	3.453***
	[0.453]	[0.478]	[0.533]	[0.467]
Population importer	-16.611***	-10.642***	-15.629***	-9.106***
	[1.957]	[1.768]	[2.019]	[1.399]
Population exporter	10.223**	14.527***	10.070***	15.162***
	[4.336]	[4.133]	[3.460]	[3.153]
Distance	-0.872***	-0.491*	-0.221	-0.112
	[0.151]	[0.261]	[0.170]	[0.157]
Transparency	-0.028*	-0.010*	-0.025***	-0.008
	[0.014]	[0.006]	[0.007]	[0.008]
Tariff	-0.089	-0.089***	-0.104	-0.096***
	[0.095]	[0.031]	[0.091]	[0.032]
Similarity	-0.864*	-0.628***		
	[0.514]	[0.228]		
Border	0.897	0.127	1.071*	0.178
	[0.585]	[0.534]	[0.601]	[0.560]
Language	1.721***	1.061***	1.351***	0.999***
	[0.276]	[0.243]	[0.390]	[0.267]
Argentina			1.632**	0.607*
			[0.685]	[0.310]
Brazil			-8.344**	-12.155
			[3.351]	[11.021]
Chile			-17.500***	-8.571***
			[4.426]	[2.355]
China			9.676	14.757*
			[9.029]	[8.734]
New Zealand			-2.398	-2.108
			[2.630]	[2.282]
South Africa			-7.427	-11.699***
			[5.394]	[2.686]
EU25			-0.78	-0.738
			[0.841]	[0.479]
Constant	-237.434	-368.733***	-232.361	-402.170***
	[161.884]	[109.980]	[145.052]	[66.555]
Country Fixed Effects	YES	YES	YES	YES
Time Fixed Effects	YES	YES	YES	YES
RESET	0.6504	0.7964	0.4239	0.714
VUONG Test		YES		YES
Observations	5525	5525	5525	5525

Robust standard errors in brackets - *significant at 10%; ** significant at 5%; ***significant at 1%

4 Conclusion

The impact of MRL of pesticides on trade has been widely studied, but the focus is often put on trade from developing countries affected by the stringency of developed countries regulations. Moreover, in all studies only one or two main substances are taken into account whereas the list of pesticides settled down in the regulations are often impressive as it is the case for apples and pears.

The aim of our analysis is to understand the role of pesticides MRL regulations on trade. We focus on apples and pears which are fruits mainly traded between developed countries as they grow principally in the temperated zone. We are interested in the way (dis)similarity in regulations can affect trade. As a first step, we build an index of similarity between exporters and importers regulations. This index is based on the values of MRL for all the pesticides found in the regulations of countries under scrutiny. Then we introduce this index as an exogeneous variable in a gravity equation.

The econometric results show, as expected, that similarity is globally trade enhancing. That is to say that increasing the similarity of regulations would lead to an increase in the value of trade. But this result must be mitigated on a case by case basis because on the apples and pears market developed countries compete with developing or emerging ones. For Argentina and China, emerging countries of high degree of similarity with importers regulations ($SIM \leq 1$), increasing similarity may prove trade-diverting. For Chile, South Africa and Brazil, emerging or developing countries with lower degree of similarity and applying the Codex, increasing similarity may impact trade positively (even though for Brazil the coefficient is not significant). Finally, for the EU25 and New Zealand, the richest countries of the exporter sample, the standards of importers do not act as a barrier and increasing the similarity with their partners would have no effect on trade.

Stringency in regulations of developed markets act in a twofold way. It increases the competitiveness of developed exporters and of developing exporters which make the effort to adapt their production process. It reduces the one of developing exporters like Brazil, Chile or South Africa which choose to impose lesser constraints on their producers. This state of fact is going to continue as it is hardly plausible that developed countries will increase the level of tolerance of residues in the future. It is often difficult for producers of developing countries to respect the standards set out in developed markets. Indeed, even if a producer succeeds in complying with the requisite imposed in the importing country, the low level of standards in force in its country could be harmful to its reputation.

Finally the results also suggest that the impact of food safety standards on trade is now more significant than the impact of tariff which have been on continuous decline.

5 Acknowledgement

This work was financially supported by the NTM-Impact project, funded by the European Commission (Specific Targeted Research Project, Contract no. FP7 KBBE.2008.1.4.05). The authors are solely responsible for the contents of this document. The authors would like to thank people from Homologa and particularly Yvonne Powell-Wainwright to have given them temporary free-access to their database.

6 References

Anderson, J. E., van Wincoop, E., 2003. Gravity with gravitas: A solution to the border puzzle. Am. Econ. Rev. 93(1):170-192.

Anderson, J. E., van Wincoop, E., 2004. Trade costs. J. Econ. Lit. 42(3):691-751.

Anderson, K., 2009. Terroir rising? varietal and quality distinctiveness of australia's wine regions. Enometrica, 2(1).

Anderson, K., 2010. Varietal intensities and similarities of the world's wine regions. Technical report, Revision of a Contributed Paper presented at the AARES/AAWE Workshop on The World's Wine Markets by 2030, Adelaide Convention Centre, 8-9 February 2010. WP available At http://www.adelaide.edu.au/cies/research/wine/pubs/AndersonVarietal_WC02010.pdf. Unpublished results

Burger, M., van Oort, F., Linders, G.-J., 2009. On the specification of the gravity model of trade: Zeros, excess zeros and zero-inflated estimation. Spat. Econ. Anal. 4(2):167-190.

Cameron, A. C., Trivedi, P. K., 1998. Regression Analysis of Count Data. Cambridge University Press.

Disdier, A.-C., Fontagné, L., Mimouni, M., 2008. The impact of regulations on agricultural trade: Evidence from the sps and tbt agreements. Am. J. Agr. Econ. 90(2):336-350.

Harris, M. N., Kónya, L., Mátyás, L., 2002. Modelling the impact of environmental regulations on bilateral trade flows: Oecd, 1990-1996. The World Econ. 25(3):387-405.

Henson, S., Brouder, A., Mitulah, M., 2000. Food safety requirements and food exports from developing countries: The case of fish exports from kenya to the european union. Am. J. Agr. Econ. 82(5):1159-1169.

Jaffe, A. B., 1986. Technological opportunity and spillovers of r&d: Evidence from firms' patents, profits, and market value. Am. Econ. Rev. 76(5):984-1001.

Li, Y., Beghin, J., 2010. A meta-analysis of estimates of the impact of technical barriers to trade. Paper provided by Iowa State University, Department of Economics in its series Staff General Research Papers with number 31968 available at http://www.econ.iastate.edu/sites/default/files/publications/papers/p11968-2010-09-03.pdf Unpublished results

Moenius, J., 2006. The good, the bad and the ambiguous: standards and trade in agricultural products. Paper prepared for the iatrc summer symposium "food regulation and trade: Institutionnal framework, concepts of analysis and empirical evidence", bonn, germany, may 28-30 2006, International Agricultural Trade Research Consortium. Unpublished results.

Mullahy, J., 1986. Specification and testing of some modified count data models. J. Econom. 33:341-365.

Oguledo, V.I., Macphee, C.R., 1994. Gravity Models: a reformulation and an application to discriminatory trade agreements. Appl. Econ. 26(2):107-120.

Otsuki, T., Wilson, J. S., Sewadeh, M., 2001a. Saving two in a billion: quantifying the trade effect of european food safety standards on african exports. Food Policy, 26(5):495-514.

Otsuki, T., Wilson, J. S., Sewadeh, M., 2001b. What price precaution? european harmonisation of aflatoxin regulations and african groundnut exports. Eur. Rev. Agr. Econ. 28(3):263-284.

Santos Silva, J., Tenreyro, S., 2006. The log of gravity. Rev. Econ. Stat. 88(4):641-658.

Santos Silva, J. and Tenreyro, S., 2010. On the existence of the maximum likelihood estimates in poisson regression. Econ. Lett. 107(2):310-312.

Vigani, M., Raimondi, V., Olper, A., 2010. GMO regulations, international trade and the imperialism of standards. LICOS Discussion Papers 25510, LICOS - Centre for Institutions and Economic Performance, K.U.Leuven, available at http://www.econ.kuleuven.be/licos/DP/DP2010/DP255.pdf. Unpublished results.

Wilson, J., Otsuki, T., 2003 Food safety and trade: Winners and losers in a non-harmonized world. J. Econ. Integr. 18(2):266-287.

Wilson, J., Otsuki, T., 2004. To spray or not to spray: pesticides, banana exports, and food safety. Food Policy, 29(2):131-146.

Wilson, J., Otsuki, T., Majumdsar, B., 2003. Balancing food safety and risk: do drug residue limits affect international trade in beef? J. Int. Trade Econ. Dev. 12(4):377-402.

Xiong, B., Beghin, J. C., 2010. Aflatoxin redux: Does european aflatoxin regulation hurt groundnut exporters from africa? Staff General Research Papers 31595, Iowa State University, Department of Economics, available at
http://www.econ.iastate.edu/sites/default/files/publications/papers/p11595-2010-07-02.pdf .
Unpublished results.

Appendix

Table A.1: Trade in apples (fresh) in 2009

Main Exporters	Value	Quantity	Main Importers	Value	Quantity
	$US Mo	**1000 tons**		**$US Mo**	**1000 tons**
Italy (EU)	758.06	798.30	United Kingdom (EU)	640.42	523.02
France (EU)	695.08	693.22	Germany (EU)	621.93	668.84
USA	651.29	663.47	Russian Federation	453.23	931.23
China	512.65	1019.80	Netherlands (EU)	366.91	358.42
Chile	489.11	774.56	Spain (EU)	260.51	258.91
Netherlands (EU)	354.35	378.26	Mexico	247.96	219.81
Belgium (EU)	268.11	342.05	Belgium (EU)	210.88	227.63
New Zealand	265.30	322.49	USA	210.53	206.60
South Africa	212.66	334.34	Canada	178.70	180.49
Poland (EU)	173.29	449.73	Lithuania (EU)	91.93	172.38

Source: COMTRADE (EU's figures contain intra-EU trade)

Table A.2: Trade in pears (fresh) in 2009

Main Exporters	Value	Quantity	Main Importers	Value	Quantity
	$US Mo	**1000 tons**		**$US Mo**	**1000 tons**
Netherlands (EU)	319.28	320.01	Russian Federation	314.25	379.15
Argentina	271.29	454.71	Germany (EU)	224.98	177.67
Belgium (EU)	264.19	284.49	United Kingdom (EU)	159.23	130.01
Italy (EU)	226.88	180.23	USA	146.28	107.69
China	161.71	405.29	Netherlands (EU)	138.80	138.63
USA	157.93	155.07	France (EU)	130.58	128.80
South Africa	118.39	174.95	Italy (EU)	117.20	112.44
Spain (EU)	91.36	96.41	Brazil	98.05	137.44
Chile	74.92	119.72	Mexico	88.39	85.85
Rep. of Korea	49.18	19.98	Canada	83.12	79.19

Source: COMTRADE (EU's figures contain intra-EU trade)

Table A.3: Trade in apples (juice) in 2009

Main Exporters	Value	Quantity	Main Importers	Value	Quantity
	$US Mo	**1000 tons**		**$US Mo**	**1000 tons**
China	655.51	799.52	USA	486.40	296.66
Germany (EU)	228.39	316.17	Germany (EU)	340.72	375.80
Austria (EU)	139.46	110.75	United Kingdom (EU)	132.70	142.84
Italy (EU)	67.52	78.49	Japan	116.21	80.67
Argentina	41.44	42.23	Netherlands (EU)	99.83	65.34
Chile	40.32	38.15	Russian Federation	88.60	88.52
USA	38.35	31.24	Austria (EU)	82.03	112.65
Turkey	38.20	37.59	France (EU)	77.47	107.23
Netherlands (EU)	38.16	23.14	Canada	62.22	39.53
Belgium (EU)	28.05	24.30	Belgium (EU)	46.86	52.73

Source: COMTRADE (EU's figures contain intra-EU trade)

Table A.4: Trade in pears (preserved) in 2009

Main Exporters	Value	Quantity	Main Importers	Value	Quantity
	$US Mo	**1000 tons**		**$US Mo**	**1000 tons**
China	50.54	54.42	France (EU)	39.00	27.19
Italy (EU)	47.74	35.70	USA	36.99	28.03
South Africa	29.99	52.23	Germany (EU)	30.42	23.38
Netherlands (EU)	9.71	6.44	United Kingdom (EU)	14.82	9.65
Thailand	9.09	4.20	Canada	10.11	8.12
USA	8.12	7.16	Belgium (EU)	8.96	5.73
Germany (EU)	8.04	5.02	Thailand	8.03	7.81
Australia	6.64	4.41	Japan	7.43	5.28
France (EU)	4.32	2.09	Netherlands (EU)	7.27	5.30
Argentina	3.05	3.46	Austria (EU)	5.68	5.06

Source: COMTRADE (EU's figures contain intra-EU trade)

Figure A.1: Representation of the SIM index for apples

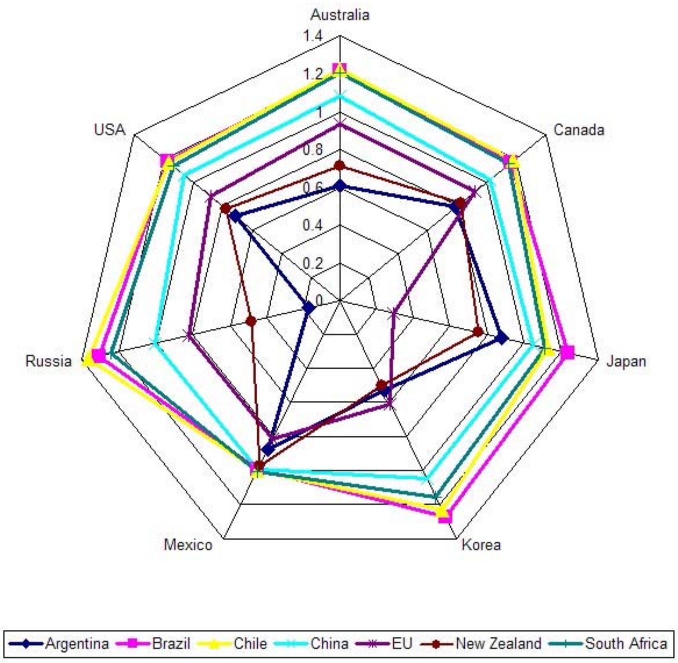

Figure A.2: Representation of the SIM index for pears