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Apples, Pears and Pesticides
Impact of Heterogeneous Regulations Governing Pesticide Residues on World Trade

Rules governing food production and trade are more and more stringent as regards safety. This is particularly the case of pesticides used in agriculture which may cause harmful effects if their concentration in food is excessive. Warnings about the effects of pesticides on health led the legislator to regulate pesticide residue content in farm produce by fixing Maximum Residue Limits (MRL). These MRL apply to both domestic and foreign products. Compliance with these regulations generates a cost for the producer or exporter which directly impacts the product price at final consumer level. This compliance is made all the more difficult as the MRL are not harmonized at international level and there are almost as many regulations as nations. There is an "international regulation" fixed by the Codex Alimentarius but it is not compulsory and nations preserve their sovereignty. Here we study the impact of regulations governing the maximum pesticide residue limits on world trade. An empirical analysis carried out on forty countries exporting and/or importing apples, pears and processed products show that overall, regulatory heterogeneousness may be trade-impeding and that international harmonization of the MRL might have a positive impact on trade. But a case-by-case analysis shows that adopting a single regulation would not have a positive impact for all countries. Harmonization would even have a negative impact on exports of pears and apple from Japan and the United States.

Very heterogeneous regulations on pesticide residues

It is generally accepted that health regulations are trade-impeding because they increase trade costs: information research costs, and in particular compliance costs. However, some authors such as Disdier (2008) show that health regulation effects on trade are not always as clear-cut. These regulations also provide information to consumers, information that may contribute to confirming his/her confidence and increase his/her consumption of the products concerned. In this case, health regulations are favourable to trade. The Maximum Residue Limits (MRL) of pesticides are among the regulations likely to reinforce consumer confidence.

Nevertheless, in the case of MRL of pesticides, there is some weight to the argument that the heterogeneousness, or even opacity, of health regulations makes trade much more difficult because these Maximum Limits are not at all harmonized at international level (see table 1). The World Health Organisation via the codex alimentarius (hereafter "codex") sets an "international standard" but it has no mandatory nature. Moreover, while many countries do make efforts to disseminate information, it is not always easily accessible.

Table 1: Number of pesticides regulated per country, and "default" regulation

	Amount of pesticides declared for apples	Amount of pesticides declared for pears	Rule applied when pesticide is not declared
Argentina	108	92	1- Codex value 2- Zero tolerance
Australia	175	160	Zero tolerance
Brazil	175	12	Codex value
Canada	93	83	Default limit of 0.1 mg/kg
Chile	103	91	Codex values
China	57	66	1- Codex values 2- Adoption of the MRL of a country of reference (EU and USA)
EU	526	526	Default value of 0.01mg/kg
Japan	391	767	Default value of 0.01mg/kg
Korea	236	210	1- Codex values 2- MRL of most similar product or group of products (e.g.: fruit) 3- Default value of 0.01mg/kg
Mexico	72	105	Zero Tolerance
New Zealand	112	107	1- Codex values 2- Acknowledgement of MRL set by Australia 3- Default value of 0.1mg/kg
Russia	124	122	1- Codex values 2- Acknowledgement of MRL set by EU and Chile 3- MRL of most similar product or group of products (e.g.: fruit) 4- Values of country of origin
South Africa	130	107	Codex values
United-States	799	799	Zero tolerance

Source: Drogué and DeMaria (2012)

The legal limits appear to be extremely variable between countries. They vary in terms of substance covered as well as in terms of tolerance levels. Some countries have very strict regulations which cover a large number of substances, fix much lower MRL than the Codex and adopt zero tolerance for very dangerous substances or for substances for which the toxicological data do not permit an Acceptable Daily Dose (ADD, see frame 1). This is, for example, the case of the United States and the European Union. Other countries like Brazil, Chile or South Africa only regulate certain substances and use the international standard set by the Codex Alimentarius as a reference for other pesticides. Other countries like China, Russia or New Zealand also recognize in some special cases the exporting country's standard (see table 1).

A measure of the "regulatory distance"

The connection between trade and regulations on toxic or harmful substances has often been studied by economists. The literature has highlighted the negative impact of a reduction in tolerance thresholds on trade in developing countries and most authors argue that a harmonization of the rules at international level is desirable. However, a large number of these analyses only take into account the standard imposed by the importing country and not the difference between this standard and that of the exporting country. For a foreign producer, the establishment of a norm, a standard or a regulation will be all the more penalizing if that producer is not subject to the same level of regulation in his/her country. Adapting the regulatory restrictions imposed by the importing country will represent an additional effort in terms of production costs. The idea developed here is to compare the regulation levels two by two and assess the impact of this gap between regulation levels, or "regulatory distance". The regulatory distance is assessed using a classical statistical indicator such as the Pearson distance (see frame 2). This indicator is between 0 and 2. If the indicator is equal to 0, this means that the regulations are identical. The higher the indicator value, the greater the regulatory distance between the two countries.

We compared the regulations concerning the MRL of pesticides for fresh apples, pears and associated processed products (dry apples, apple juice and canned pears) on a sample of 40 importing countries (the 27 Member states of the European Union (EU), Argentina, Australia, Brazil, Canada, Chile, China, Japan, Korea, Mexico, New Zealand, Russia, South Africa and USA) and 38 exporting countries (the same as before except Mexico and Russia which are mainly importers). The values of our indicator are reported in tables 2 and 3.

Table 2: "Distance" Matrix between national regulations on MRL of pesticides (apples)

Apples	Austr.	Brazil	Canada	Chile	China	UE27	Japan	Korea	Mexico	N. Zel.	Russia	USA	S. Afr.
Argentina	0,85	1,33	0,79	1,31	1,32	1,02	0,88	0,53	0,87	0,94	0,17	0,90	1,28
Australia		1,06	0,95	1,05	1,06	1,03	0,96	0,91	1,00	0,99	0,83	0,97	1,06
Brazil			1,16	0,30	0,26	0,90	1,23	1,27	0,99	0,97	1,30	1,05	0,30
Canada				1,14	1,15	1,03	0,89	0,86	0,95	1,00	0,79	0,93	1,15
Chile					0,28	0,88	1,10	1,26	0,98	0,95	1,29	1,01	0,37
China						0,88	1,11	1,19	0,98	0,95	1,29	1,01	0,34
EU							0,93	0,97	1,01	0,93	1,02	0,93	0,87
Japan								0,50	0,97	1,00	0,89	0,94	1,11
Korea									0,98	0,95	0,54	0,94	1,16
Mexico										0,84	0,90	0,99	1,00
New Zealand	0,00										0,94	1,02	0,96
Russia				0,23		0,00						0,93	1,24
USA													1,03

Source: Drogué and DeMaria (2012),

Note: The matrix is not symmetric because New Zealand recognizes the MRL for food from Australia and Russia recognizes those from the EU and Chile.

Table 3: "Distance" Matrix between national regulations on MRL of pesticides (pears)

Pears	Austr.	Brésil	Canada	Chili	Chine	UE27	Japon	Corée	Mexique	N. Zel.	Russie	USA	Af. du S.
Argentina	0,78	1,38	0,88	1,33	1,32	0,96	0,67	0,49	0,92	0,93	0,16	0,89	1,30
Australia		1,09	0,95	1,07	1,08	1,01	0,88	0,87	0,98	0,98	0,76	0,95	1,07
Brazil			1,14	0,26	0,20	0,92	1,22	1,28	0,97	0,99	1,35	1,02	0,25
Canada				1,11	1,13	1,03	0,90	0,87	1,00	1,01	0,89	0,97	1,14
Chile					0,30	0,89	1,17	1,27	0,96	0,95	1,27	1,01	0,36
China						0,89	1,17	1,21	0,97	0,95	1,28	1,01	0,33
EU							0,93	1,02	1,01	0,92	0,95	0,93	0,89
Japan								0,71	0,99	0,98	0,79	0,90	1,17
Korea									1,01	0,94	0,50	0,96	1,18
Mexico										0,79	0,94	1,01	0,99
New Zealand	0,00										0,93	1,01	0,96
Russia				0,24		0,01						0,92	1,25
USA													1,01

Source: Drogué and DeMaria (2012).

Note: The matrix is not symmetric because New Zealand recognizes the MRL for food from Australia and Russia recognizes those from EU and Chile

In the light of these results, we can say that regulations on MRL of pesticides are not too "distant" from each other. Our indicator value is on average equal to 1. Conversely, there is a real difference between countries which use the International Standard of the Codex Alimentarius (Brazil, Chile, China, and South Africa). The indicator value is almost always higher than 1 when countries which use the Codex norm and those which have their own standard are compared. This result would tend to confirm that national regulations are rather distant from the international norm, usually stricter.

Frame 1: Definitions and calculation mode of MRL on pesticides

The Food and Agriculture Organization (FAO) defines pesticides as any substance or association of substances intended to repel, destroy or control pests (vectors of human or animal diseases included) and unwanted species of plants or animals causing harm to or interfering with the production, processing, storage, transport or trade of food products, farm produce, wood and wood products, or animal feedstuffs or substances which can be administered to animals for the control of insects, arachnids and endo- or ecto-parasites. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent for fruit thinning or preventing premature fall of fruit, and substances applied to crops, either before or after harvest to protect the commodity from deterioration during transport or storage.

According to the FAO, the MRL is the maximal concentration of a residue legally permitted or considered acceptable in or on a food product, farm produce or a product intended for animal feeding.

When a product is approved, studies on residues are made in order to determine the residue level which could remain in the harvest in the worst case (worst case scenario). For this purpose, the product studied is applied at the maximum of its recommendation for a given crop.

By using the MRL fixed during experimentations, an assessment of the Theoretical Maximum Daily Intake (TMDI) is made. This assessment checks that the average consumer (60kg for an adult, 6.2kg for a baby) does not ingest a higher amount of active substance than the Daily Admissible Doses (DAD). The sum of all the potential residues that may be ingested in one day (according to the food diet of the various population categories) must not exceed DAD. All vegetable and animal products are taken into account in this calculation.

Frame 2: A gravity model to assess impact of regulatory distance

To assess the impact of the heterogeneousness of health regulations governing pesticide residues, we use an econometric model such as the one described in Disdier (2008). This basic model is completed by variables which take into account the specificities of our analysis. This model is written (with i and j respectively denoting the exporting and the importing country, and k denoting the product, apples or pears):

$$\ln\left(X_{ijt}^{k}\right) = \beta_0 + \beta_1 \ln\left(GDP_{jt}\right) + \beta_2 \ln\left(PROD_{it}^{k}\right) + \beta_3 \ln\left(Dist_{ij}\right) + \beta_4\, Border_{ij} + \beta_5 Lang_{ij} + \beta_6 \ln\left(SIM_{ij}^{k}\right) + \beta_7 \ln\left(Tarif_{ijt}^{k}\right) + \beta_8 Transp_{ijt} + \beta_9 DispJapUsa_t + \beta_{10} DispAusNzl_t + \beta_{11}\, SPS_{ijt}^{k} + \beta_{12} EU_t + \alpha_i + \alpha_j + \alpha_k + \alpha_t + \varepsilon_{ijt}^{k}$$

This model regresses the bilateral trade value of apples and pears (*X*) on variables such as the importing country's *GDP*, the production level of the exporting country (*PROD*), the distance between the two countries (*DIST*), the existence of a common border and/or language (*Border and Lang*), the regulatory distance (*SIM*), the tariff barrier (*Tariff*), an indicator which measures the gap between the countries in terms of quality of institutions (*Transp*), variables on trade disputes which may have arisen between sample countries regarding apples and pears (*DispjapUsa*,*DispAusNzi* and *SPS*) and lastly a variable which takes into account the EU enlargement to 25 then 27 Member states (*EU*). Data come from several sources: UN/COMTRADE for trading, World Bank for GDP, FAO for production, CEPII for distances and the existence of a common border and language, WTO for tariff barriers.

SIM^{k}_{ij} is the distance associated with the Pearson correlation coefficient and is calculated as follows : $SIM_{ij}^{k} = 1 - \left(\frac{1}{n}\sum_{p=1}^{n}\left(\frac{x_{ip}^{k}-\bar{x}_{ip}^{k}}{\sigma_i^{k}}\right)\left(\frac{x_{jp}^{k}-\bar{x}_{jp}^{k}}{\sigma_j^{k}}\right)\right)$

Where x_{ip}^{k} is the MRL of pesticide *p* imposed by country *i* on product *k*. *n* is the total number of pesticides and σ is the standard deviation.

The model's basic assumption is that the trade cost is proportional to the tax intensity and rigidity of certain regulatory measures such as the MRL of pesticides. The selected estimation method is a two-step technique which first assesses the impact of the variables on the likelihood of trade existing between two countries, then quantifies the impact of these same variables on the size of the trade. During the first step, we isolate the couples of countries in two groups. The first "Always zero" group includes the couples which have a null trading probability, and the second, "Not Always zero", the couples which have a non-null trading probability that the trade flow is positive or null. In the second step, only the "Not Always zero" part of the sample is considered. The model is estimated on pooled data between 2000 and 2009.

Adopting an international standard on pesticide residue limits would be quite favourable to trade

The question here is whether the establishment of various health regulations affects trading relationships between countries. An econometric model of the gravity type (see frame 2) was built to measure the impact of the regulatory distance between countries as regards the MRL of pesticides on the trade of apple and pear (fresh and processed). Overall the results obtained are those expected (see table 3), but the most interesting are the values of coefficients of three variables: distance in kilometres (*Dist*), tariff barriers (*Tariff*) and regulatory distance (*SIM*).

Table 4: Estimated elasticities and likelihoods of absence of trade flow

Variables	Elasticities	Probability of absence of trade flow
GDP	1.64***	-0.48***
Prod	0.78***	-0.68***
Dist	-0.54***	1.05***
Border	0.88***	-2.07***
Lang	0.27**	-1.25***
Transp	0.03*	0.10*
Tariff	-0.01	0.11***
EU	-0.61	-1.12
SIM	-0.16***	-0.02

Note: Symbols *, **, *** indicate that coefficients are significant at 10%, 5% and 1% respectively. Source: Drogué and DeMaria (2012)

In table 4, the elasticities measure the expected impact of the variable analysed on the size of the bilateral trade flow. The probability of absence of flow gives us information on the expected impact of the variable on the very existence of a trade flow between the countries of the sample. The results show that the "physical" distance (*Dist*) impacts the probability of establishing a trade relationship as much as the effective trade volume. The elasticity of variable (*Sim*) is negative and significant indicating that the trade volume falls as the "regulatory" distance increases. On the other hand, this variable has no impact on the existence of trade (coefficient not significant), unlike tariffs (*Tariff*) which chiefly affect the establishment of a trade relationship. To sum up, these results show that the closer the countries are physically, the higher the probability that they will establish a trading relationship and the higher the trade flow between them. The more similar the regulations on MRL of pesticides (the more similar they are in "regulatory" terms), the higher the trade volume, but differences do not hinder the establishment of trade relationships. Finally, the tariff level affects the existence of a trading relationship which, once established, is less sensitive to this level.

The simulation results show that while the physical distance and tariff have an impact on the probability of existence of trading flows, the "regulatory" distance only has an impact on the trade volume. In other words the existence of very different regulations between trading partners does not discourage exporters from entering foreign markets, but it would limit the size of their exports.

Table 5: regulatory distance impact per country

Variables	Elasticities	Probability of absence of trade flow
Total effect (SIM)	-0.31***	-0.14***
Argentina	-0.44	0.27
Australia	-0.12***	0.25
Brazil	-1.21	-0.37
Canada	-14.49**	0.13
Chile	-0.86	-0.58
China	-2.179***	-1.85**
Korea	3.34	1.19
Japan	1.50**	-0.42
New Zealand	-16.31***	5.46
South Africa	2.35	-0.98
USA	32.83***	-14.63***
European Union	-0.09***	0.15**

Note: symbols *, **, *** indicate that coefficients are significant at 10%, 5% and 1% respectively.
Source: Calculation of the marginal effects from Drogué and DeMaria, 2012.

We re-estimated the model by introducing an interaction variable between the measure of the regulatory distance and the fixed effects of the exporting country (on fixed effects, see Emlinger et al, 2009). This interaction variable allows us to assess the impact of regulatory distance country per country. Results are shown in table 3.

When we analyse country by country, the results are more ambiguous. As far as Australia, Canada, Brazil, China, New Zealand and the EU are concerned, reducing the regulatory distance with trading partners would have a positive effect on their exports, as in the general case. This impact would be null for Argentina, Brazil, Chile, Korea and South Africa. However, a regulatory harmonization would have a negative effect on trade from the USA and Japan. This result would tend to confirm that international regulatory harmonization is not necessarily desirable across all countries, especially if this harmonization results in a less stringent regulation than the previous one. In some cases, regulatory harmonization can be trade-diverting. In the specific case of the USA which has high production costs, we may interpret this as the loss of a positive signal which would make consumers turn to other much more competitive suppliers.

In conclusion, adopting an international standard such as that set by the Codex on MRL of pesticides would have a positive global effect on trade. However, a country by country analysis compromises this slightly as the impact on the trade of some of the countries would be null, or even negative.

Accepting a common standard would result in the creation of trade diversions towards the cheapest supply sources since the information conveyed by the regulation would become the same for all of them.

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