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Full Research Article

Measuring the complexity of complying with phytosanitary standard: the case of French and Chilean fresh apples

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Abstract. Nowadays, complying with technical, sanitary and phytosanitary (SPS) regulations and standards is becoming more and more demanding due to their proliferation and increasing complexity. Consequently, increasing requirements in plant health protection and food safety can lead to a loss of competitiveness in countries that are major exporters of fresh products, causing a redistribution of the market shares in certain sectors. Exporters complying with regulatory standards benefit from better market access and avoid boarder rejection or product downgrading but incur additional costs due to additional procedures and paperwork. This is the case for French apples producers which are losing competitiveness compared to the Chilean ones on foreign markets. This situation can be partially explained by the difficulties of French exporters to comply with international SPS requirements. The aim of this article is first to make a compilation of phytosanitary requirements facing French and Chilean exporters of fresh apples, then to propose a score (hereafter phytosanitary score) which allows to assess the degree of complexity of these SPS requirements. This score is interesting as it synthesizes qualitative information in a metric which can be easily used in quantitative analysis. The results show that even if France and Chile are rather close in terms of SPS requirements, Chilean apples exporters are more capable to comply with foreign SPS requisites than the French ones.

Keywords. Cost of compliance, scoring, apples, sanitary and phytosanitary regulations.

JEL codes. C51, I18, Q18.

1. Introduction

The literature on sanitary and technical regulations has shown that if regulations and standards are market facilitators by decreasing asymmetries, they also hamper trade (Swinnen and Vandemoortele, 2011; Marette and Beghin, 2010). The effects that SPS regu-

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lations have on the economy depend on how they impact consumers, domestic producers and foreign competitors (Swinnen and Vandemoortele, 2009). The cost of production and marketing will increase with the increasing complexity of the regulations abroad. *In the importing country, compliance with a regulation involves a cost to foreign suppliers, which acts like a trade tax, resulting in a deadweight loss as well as transfers from consumers to producers* (Beghin and Bureau, 2002). On a specific market, foreign producers are impacted by the SPS requirements depending on their relative differences in the marginal cost of the regulation, thus on their relative efficiency to comply with importers' standards. This may affect countries that were major exporters, causing a redistribution of the market shares in certain sectors. It is the case for French apples exporters who compete now with newcomers as China which were not even producers 10 years ago.

International trade of apples (and more generally of fruits and vegetables), requires that products intended for marketing come with a Phytosanitary Certificate (PC) which certifies that they are properly inspected, pest-free, and comply with national and international phytosanitary regulations. However, regulatory constraints and requirements in the importing countries may differ substantially from those in the country of departure. This asymmetry directly impacts the phytosanitary risk management and therefore the costs of compliance. Usually, to deliver the PC for fresh apples, countries require either a cold treatment and/or fumigation with methyl bromide (APHIS USDA, 2014 Calvin and Krissof, 1998). The former, even if simple to apply, can become quite complicated because the required temperature for cold treatment may vary from one destination to another. Moreover, if the majority of countries agree on a pre-shipment cold treatment, others require it during transportation or even at the port of arrival complicating the procedure. But the cold treatment is one among many requirements and paperwork an apple exporter faces before selling its products abroad.

Even if a producer is able to comply with all these measures, a possible refusal of the apples still remains if at the port of arrival, a further inspection proves that something went wrong during the transportation or if the regulations have changed meanwhile. Rejections of apples occurred between the US and Japan in 2002, the US and Taiwan, Australia and New Zealand in 2007 (WTO, 2010) also between France and Vietnam in 2012 (France Agrimer, 2015).

These examples illustrate that quantifying costs of compliance is not an easy task due to the proliferation of technical and sanitary regulations and standards and to their increasing complexity. Moreover, whereas models for policy analysis often require quantitative data, these regulations are often not quantitative. *For qualitative standards, like labelling, no numerical values can be directly used. Further, these qualitative policies affect different components of costs of production and marketing and cannot be easily aggregated into a single price equivalent. Evaluating the protectionist component of these numerous qualitative policies into a protectionist score is likely to remain a challenge* (Li and Beghin, 2014). Several authors worked on the issue of introducing qualitative policy instruments in quantitative analysis by producing different synthetic indicators. Among others we can quote works on technological positions (Jaffe, 1986), regulations on Genetically Modified Organisms (Vigani *et al.*, 2011) or varieties of grapes and wines (Anderson, 2010). More recently, Ferro *et al.* (2015), Li and Beghin (2014), Winchester *et al.* (2012) or Drogué and Demaria (2012) also built synthetic metrics to compare bilateral regulations on maximum residual level of food contaminants.

In this article we build a phytosanitary score that allows approximating the relative complexity of phytosanitary requirements in the marketing of fresh apples. We compiled the sanitary and phytosanitary regulations French and Chilean apples exporters must comply with on their main markets of destination. These two countries have been chosen for two main reasons. First, at international level, in comparison with Chile, French producers are losing market share, which could be explained by their difficulties to comply with international phytosanitary regulations. The second reason lies in the characteristics of the countries themselves. France is a traditional provider of apples with a long history of production and consumption, while Chile is a more recent producer export-oriented, and, being located in the Southern Hemisphere; apples in Chile are produced off-season.

The indicator presented henceforth can be seen as a proxy for higher compliance cost born by exporting countries when shipping their apples abroad. This kind of indicator can be used in econometric models to evaluate the impact of non-tariff barriers on trade. At the same time, supply chain operators can also use it as synthetic information on the complexity of phytosanitary requirements in importing countries.

In order to compute our indicator, we first identified all the components of apples phytosanitary requirements Chile and France must comply with by destination (number of inspections, number of treatments and location of treatment, signature of an agreement between countries, etc.). Then, each component is graded with an increasing value according to its degree of complexity; finally we sum them up in a normalized score.

Results show that the scores for France and Chile are rather close, but suggest that overall France suffers from more stringent foreign regulations and Chile is able to reach more easily any destination markets thanks to a better geographical position and phytosanitary situation.

The originality of this work is a deeper understanding on sanitary and phytosanitary requirements that French and Chilean apples producers necessarily face if they decide to gain foreign markets' share, and more particularly the design of a tool that allows to grade and to translate regulatory data into a single score useful for quantitative analysis.

The paper is organized as follows: section 2 is an overview of the international market of apples and the recent redistribution of market shares between countries in this sector. Section 3 is devoted to the presentation of the data on phytosanitary requirements. Section 4 presents the building of the score. Section 5 is devoted to the sample and the numerical results. Section 6 concludes.

2. The international market of apples

Compared with other markets of agricultural commodities, such as sugar, coffee or bananas, the apple world market can be broadly considered as residual: in 1961, only 9.5% of the world fresh production was traded on international markets and reached 11% fifty years later (2012). The main reason is that, historically, traditional producing countries (essentially Western countries) were also the main consumers. From the 90s, an evolution took place in the global geography of production and consumption, leading to evolving trade flows. The description of these changes is therefore important to understand the main opportunities and obstacles encountered by the major exporting countries (like France or Chile).

Figure 1. World apple market: production (with and without China).

Source: Faostat.

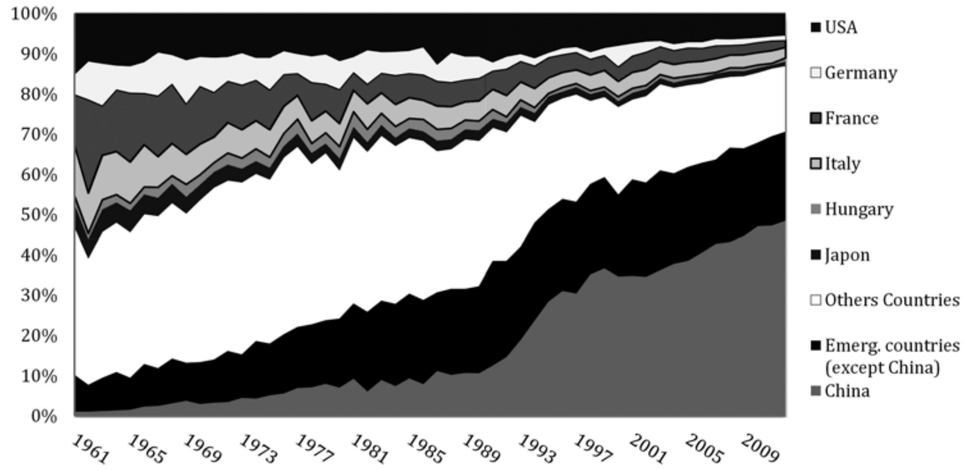
According to the FAOSTAT database, apples are nowadays the second most produced and consumed fruit in the world after bananas and before oranges and grapes. Its production evolved greatly during the last 50 years, from 17 million tons in 1961 to more than 76 million tons in 2012 (+300%). This apparently linear development, hides some recent and deep changes in the geography of production. First and foremost, there is the spectacular increase, from the beginning of the 90s, of the Chinese production (Figure 1). From just 1% of the world production in 1961, it represents today half the global output in the world (48% in 2012)[1]. In general, during this same period there is a globalisation of apple production and traditional producers (as France or Italy) have lost market shares in relative and absolute value, to the benefit of China and emerging countries (Figure 2).

On the demand side, we observe the same evolution: in countries of traditional consumption, with high incomes, saturated food demand, and with stronger health and environmental concerns, apples suffer the competition of other fruits, including exotic ones (Figure 3). In contrast, population growth recorded in emerging economies, combined with higher average incomes and the dissemination of national and international education policies promoting fruit consumption[2] explain the increase of their respective demand for fruits, especially apple, one of the easiest to store (Figure 3).

Finally, if the geographical area of apple production and consumption has greatly expanded in the last 20 years, the new consumer countries are not necessarily the producing ones. Therefore, and except for China, which is largely able to meet its own domestic

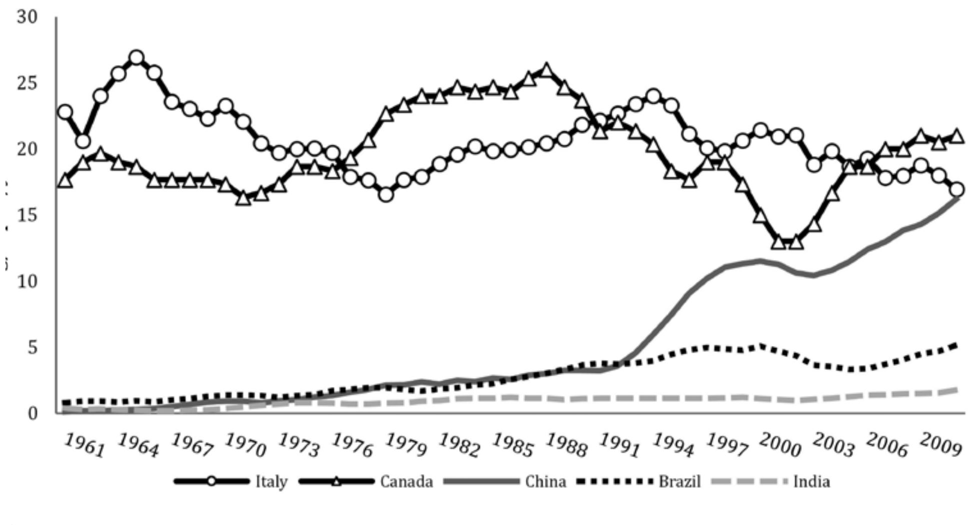
[1] What explains this phenomenon is the liberalization process of the Chinese market implemented by Deng Xiaoping (Murphy *et al*., 1992). His reforms have allowed the Chinese farmers to sell their excess production on the free market, leaving the market price system drive the allocation of productive investments.
[2] WHO: http://www.who.int/mediacentre/news/releases/2003/pr1/en/.

Figure 2. World apple market: production shares - selected countries.



Source: Faostat.

Figure 3. World apple market: per-capita apple consumption – selected countries.



Source: Faostat.

demand, the increasing consumption of apples in developing countries (like India, Indonesia or Brazil for example) represents a new opportunity for all exporters.

Among the major producing and exporting countries in 2012, Table 1 differentiates those for which the domestic market remains a priority (such as China) from those for which external demand represents a major challenge. In the latter category, Chile, France

Table 1. World apple market: production and export shares – selected countries.

Country	National production on world production (%)	National net exports on world exports (%)	National net exports on national production (%)
Italy	3.2	11.3	38.9
Chile	2.1	9.6	50.4
China	47.3	9.1	2.1
USA	5.6	8.2	16.0
France	2.4	7.1	31.7
Iran	2.4	1.3	5.7
Turkey	3.5	1.0	3.0
India	3.8	-1.8	-7.0

Source: Faostat, 2012.

and Italy[3], represent about 30% of apple's worldwide exports.

If in the following study, we limit the comparative analysis to France and Chile, thus excluding Italy, several reasons justify our choice. First, to avoid duplication effect: France and Italy have similar characteristics in terms of seasonality, produced varieties, production conditions and supplied export markets. Second, the lack of data, especially regulatory data (bilateral phytosanitary agreements), for Italy, does not allow us to add this country to the comparative analysis.

Therefore, we focus on the comparison between France and Chile. These two countries differ not only in terms of geographical location, seasonality, climate characteristics or supplied markets[4]. They also face contrasting trends in exports. French apples exports are falling in the last 20 years, while they are increasing in Chile (Figure 4). These trends can partly be explained by the differences in importers' SPS requirements.

3. Data description of phytosanitary requirements in the apple sector

Diseases and pest invasions vary greatly with place and time affecting the risk management and the protection of trees. The main pests damaging apples and apples orchards are: insects (codling moth, fire blight, sawfly insects, tortricid, aphids, and fruit tree spider mites), fungal diseases (apple scab - *Venturia inaequalis* and powdery mildew - *Podosphaera leucotricha*) and viral diseases.

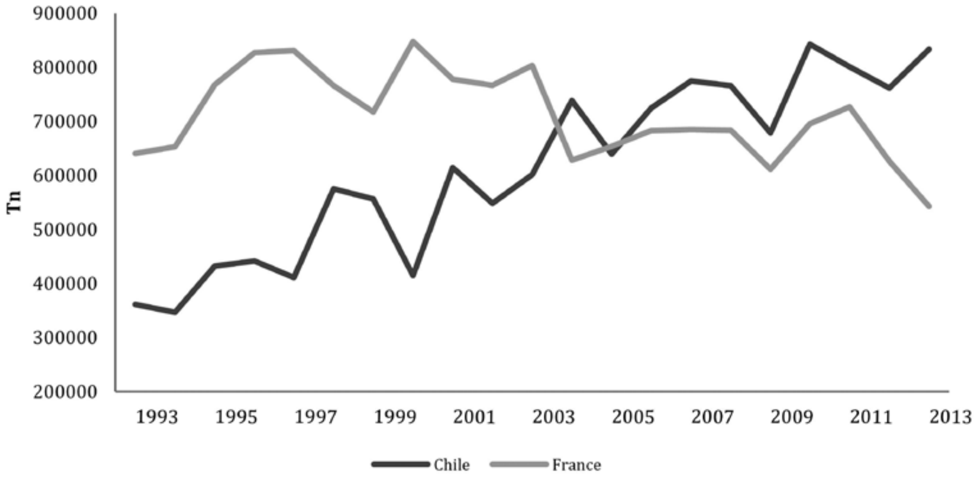
Viral diseases have been less damaging since plants carried a certificate which guarantees against the presence of the Mycoplasma-like Organism (MLO) disease, the apple mosaic or the bitter pit disease (affecting the fruit).

In order to mitigate the phytosanitary risk, regulators impose that crop products intended for marketing are accompanied by a Phytosanitary Certificate, defined above.

[3] We could add to this short list, New Zealand, a strongly export-oriented country. However, it does not represent a sufficient volume of exportations to be mentioned among the major players of the apple world market.

[4] According to the detailed trade matrices published by Faostat, France exports about 75% to EU countries and 11% to Asian countries (in particular middle east). Contrariwise, Chilean exports are more diversified: half of its exports concern the Americas (especially Canada and USA), 23% come to Asia and 23% to Europe.

Figure 4. France and Chile apple exports (1993-2013).



Source: Faostat.

These regulatory constraints and associated additional treatment operations impact the SPS risk management and increase, the costs of production and marketing. However, even if a producer is able to comply with all these measures, some possible rejection/refusal of products may still happen if at the port of arrival further inspection prove the presence of a pest. Rejections of apples occurred between the USA and Japan in 2002, the USA and Taiwan, Australia and New Zealand in 2007 (WTO, 2010) and in 2012 Vietnam stopped apples coming from France and re-negotiated a bilateral SPS agreement (France Agrimer, 2015). To illustrate the complex nature of pest risk management in the framework of international apple trade, let's take the example of cold treatment. Cold treatment is a common practice to fight main apple pests (especially *Ceratitis capitata*), which in some cases, must be associated to fumigation (APHIS USDA, 2014). The cold treatment requires that fruits must be stored at a constant temperature between 0° and 4° for a period of 14 to 21 days to prevent contamination of products by harmful organisms. Even if simple to implement, the cold treatment may become quite complicated because in case of a random interruption, the procedure must start again from the very beginning. An interruption is more likely to occur during shipment because temperature sensors cannot be verified easily and the common practice is that of cold treatment in transit[5].

Moreover, doubts about the presence of pests or harmful organism in a given area may rise the alert level with consequent tightening of controls. This happened, with Vietnam, which denied market access to its trading partners between 2013 and 2015 in order to modify the phytosanitary regulations.

In this context analysing SPS regulations imposes a case by case analysis. Therefore, for the countries under scrutiny (France and Chile) we retrieved information from vari-

[5] Source: EPPO, URL: https://www.eppo.int/QUARANTINE/data_sheets/insects/CERTCA_ds.pdf

ous sources. The first and main sources of information are the websites of the national food safety authorities managed by the respective Ministries of Agriculture (Exp@don for France and the Servicio Agricola y Ganadero (SAG) / Department of agriculture and livestock for Chile). However, in some cases information was missing, thus we also consulted the World Integrated Trade Solution (WITS) maintained by the World Bank, the World Trade Organisation (WTO) dataset and finally the International Plant Protection Convention (IPPC). All this information was crossed-checked with experts from the SRAL (Service Regional de l'Alimentation / French Food Regional Service). The analysis of all the information at our disposal allowed us to identify an exhaustive list of the many requirements apples exporters face[6]. These requirements are of two types: (i) operational as the cold treatment or fumigation: in this case the requirements from the Animal and Plant Health Inspection Service of the United States Department of Agriculture (APHIS/USDA) are the leading reference in many countries; (ii) administrative, taking the form of inspections or of declarations and can vary a lot according to bilateral agreements between the countries of origin and destination. We identify 9 requirements, called "dimensions" and described in the Box A2 in appendix.

To each dimension of the phytosanitary regulation we assigned a grade increasing with the complexity of implementation. The lowest grade is 0 (no constraints). Then, 1 when the regulation requires a form of monitoring easy to apply; a value equal to 2 or 3 when fulfilling the requirements is complex and finally the maximum value in case of a ban. For instance, the grade for the cold treatment ranges between 0 and 3. It takes a value equal to 0 if any cold treatment is required; a value equal to 1 if the cold treatment is applied in transit, a value of 2 when the regulation requires a cold treatment at the port of arrival and a value of 3 for ban. We assume that any kind of activity is more difficult or more expensive to implement in the country of destination than during the shipment or pre-shipment. Indeed (i) the absence of national operators in the foreign countries, (ii) the difficulties related to the use of different languages or different standards or (iii) the potential higher cost of the cold treatment activities in the foreign countries makes the procedure more difficult.

The ban is not difficult to implement but it prevents all imports from the banned country; this is the reason why we consider the ban equivalent to assigning the highest grade to each dimension. Table 2 displays the grades by dimension. As we can see from table 2, the number and the values of each restriction vary from country to country depending on the underlying domestic regulation. Each phytosanitary requirement is controlled and certified by the representative safety authority: the SRAL in France, the SAG in Chile. They perform the required inspections and deliver the phytosanitary certificates.

Once this evaluation has been made, in the next section we synthesize all the components into one metric which gives the relative "phytosanitary distance" between the exporter (*i.e.* France or Chile) and their importers.

4. Building a Phytosanitary Score

In order to assess the complexity of the overall SPS regulations imposed to French and Chilean apple exporters we built a Phytosanitary Score (hereafter *PS*). Follow-

[6] The analysis was carried out between 2014 and 2016. During this period, no major changes took place in trade relations, except for the negotiation of a new bilateral protocol between France and Vietnam.

Table 2. Dimensions and grades of the Phytosanitary Requirements and underlying regulations.

Dimension	Values	Underlying Regulations
Territorial Restriction / QO Restriction	0 (No restriction) 1 (Yes restriction) 2 (Ban)	**Bilateral agreements:** - between France and China, Indonesia, Sri Lanka, Taiwan, Thailand, Vietnam, USA - between Chile and China, India, Taiwan, Thailand, USA, Mexico. **In the other cases**, the information comes from: - Exp@don database (for France) - SAG database (for Chile) - Wits database (by World Bank) - Food Safety Authority of importing countries (Website)
Agreement	0 (No agreement needed) 1 (Agreement on pre-listing) 2 (Agreement on yearly check) 3 (Ban)	
Import Permission	0 (No IP needed) 1 (The IP has been negotiated) 2 (The IP has not been negotiated) 3 (Ban)	
Phytosanitary Certificate	0 (No PC) 1 (The PC has been negotiated) 2 (The PC is under negotiation) 3 (The PC is non official) 4 (Ban)	
Pre-inspection	0 (No Pre-inspection) 1 (Pre-inspection is required) 2 (Ban)	
Pre-clearance	0 (No Pre-clearance) 1 (Pre-clearance is required) 2 (Ban)	
Pre-cold treatment/fumigation	0 (No treatment needed) 1 (Treatment needed) 2 (Ban)	
Cold Treatment	0 (No cold treatment) 1 (In transit cold treatment) 2 (At arrival cold treatment) 3 (Ban)	
Inspection at arrival	0 (No inspection at arrival) 1 (Inspection at arrival) 2 (Ban)	
Total Requirements	24 (maximum requirements)	

ing Ferro *et al.* (2015), *PS* is designed as the sum of the grade obtained by each phytosanitary constraint (dimension) imposed by the importing country to the exporting one. We then normalized it in order to obtain a value ranging between 0 and 1 and further imposed convexity as in Li and Beghin (2014). In our analysis we consider that *PS* measures the relative severity of the phytosanitary constraints imposed by the importing country.

$$PS_{ij} = \frac{1}{N}\left[\sum_{t=1}^{N} \exp\left(\frac{Phyto_{ijN} - minPhyto_{N}}{maxPhyto_{N} - minPhyto_{N}}\right)\right]$$

Subscript i denotes the exporting country and j importing country (here i is equal to France or Chile), $Phyto_{ijN}$ is the grade of the requirement imposed by country j to country i in the dimension N; $maxPhyto_N$ is the highest grade in the dimension N; $minPhyto_N$ is the lowest grade in the dimension N. The PS indicator ranges between 1 (in the absence of any specific requirements) and $e \approx 2.72$ which corresponds to the case of a ban, the greater the score the more difficult to comply with all the dimensions of the country of destination's SPS regulation.

The advantage of introducing the convexity in the standard is that it imposes more weight on more demanding requirements suggesting that it is more difficult to reach higher standards and thus that the marginal cost of compliance is increasing. We are particularly interested in verifying the relationships between trade and *PS* that is to say between trade and the phytosanitary requirement (*Phyto*). Our intuition being that the two variables are negatively correlated.

5. Sample and results

Crossing data on French and Chilean apple exports during the period 1986-2013 with the sanitary regulations, we have been able to select a sample of 82 countries (over 146 destinations in 2013) for France, and a sample of 51 countries (over more than 100 destinations in 2013) for Chile (see the complete list of countries in table A1 in appendix). For the selected countries there is a positive flow of apples from France and Chile over the period and information on phytosanitary regulations is available. We exclude from our samples, countries with zero trade flows except when those countries imposed a ban on French or Chilean apples. The countries in the sample represent, for both exporters and for the entire period, 99% of their exports of apples on average.

Our sample can be disaggregated in 3 sub-groups. The first one gathers European countries which apply similar phytosanitary regulations (Directive 2000/29 CE, European Commission, 2000). In this common phytosanitary area, French apples move freely without control or particular certificates, while Chilean apples need a simple inspection at arrival. The second sub-group gathers 52 extra-European destinations for which French and Chilean apples must be accompanied by a PC or by a specific phytosanitary document or both. The third group is constituted by countries which banned imports of apples from France or Chile (Indonesia, Japan, South Africa, South Korea and Tunisia).

Table A1 in appendix reports the values of the scores for all countries importing French or/and Chilean apples. It shows in the first column the selected countries importing apples from France; in the second column the values of *PS*; and in the third column the average trade in volume. Columns 4 to 7 display the same information for Chile.

This score is able to capture the degree of complexity of the regulation. In order to test the relationship between trade and the score we proceed by simple correlation analysis.

In Figure 5 and 6, we can appreciate the position of both exporting countries in comparison to their own trading partners. It is interesting to note that the distribution of the phytosanitary score (*PS*) seem comparable in the two graphs: the group of European countries is always on the left of the distribution, while the group essentially composed by Asian countries is, in both cases, on the right. This illustrates that European countries apply relatively looser regulatory restrictions compared to Asian countries, regardless

Figure 5. *PS* Country Mapping (France).

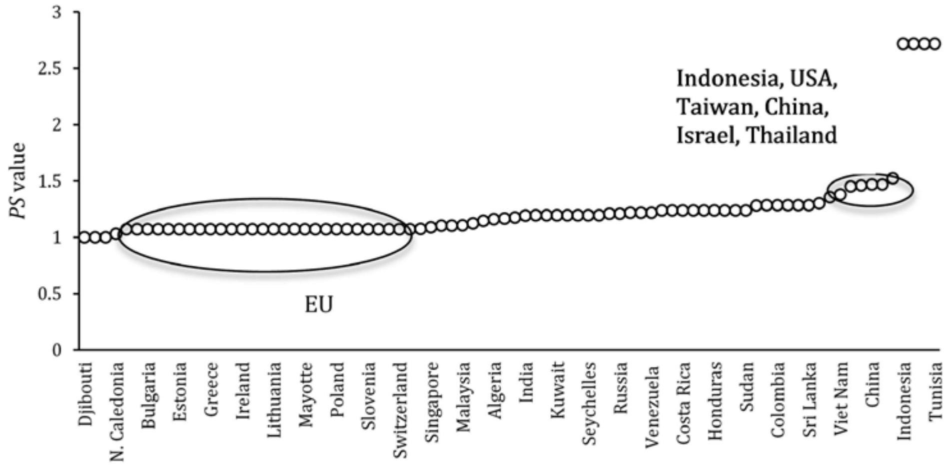
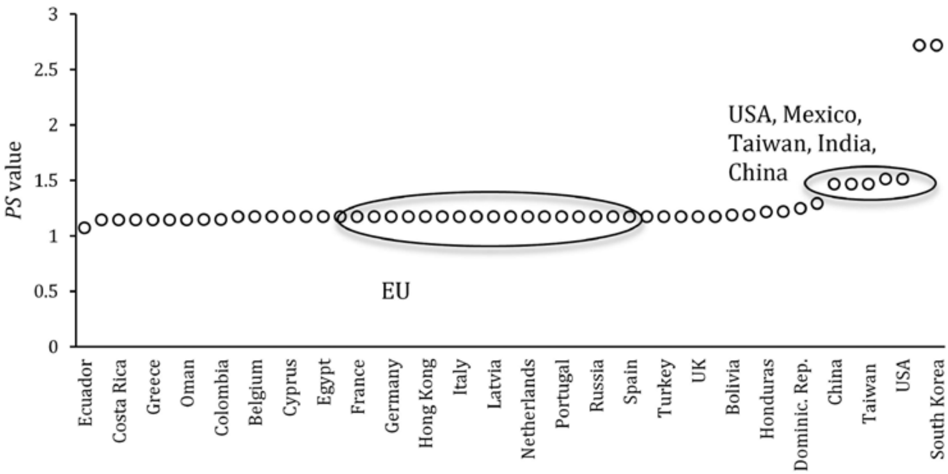


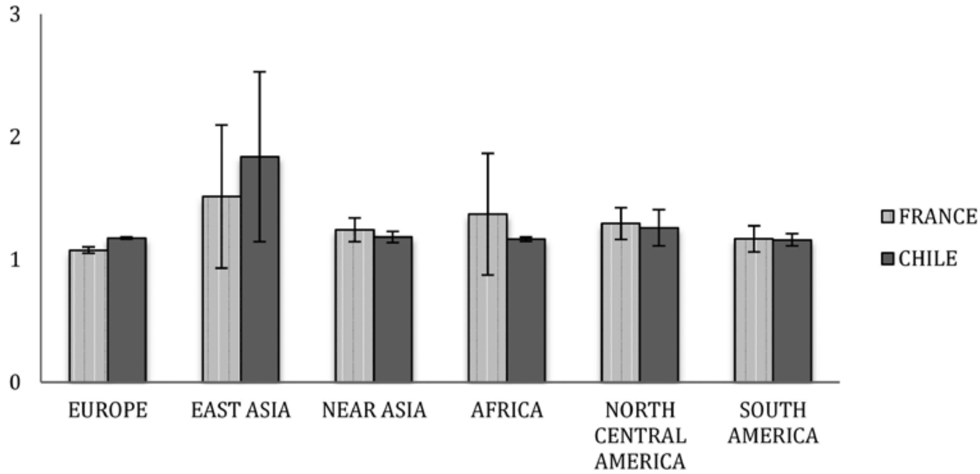
Figure 6. *PS* Country Mapping (Chile).



of the source of exports. However, while it is obvious that France belongs to the group of European countries (as importer, Figure 6), it is also important to note that Chile as importer, belongs to the group of countries applying more complex regulations (as China, Indonesia, Taiwan, Thailand, or the USA).

The box plot in Figure 7 shows the distribution of *PS* by region. In this figure the higher the boxes the more demanding the phytosanitary requirements between France or Chile and their clients. First, we can observe that both exporters face similar average level of complexity by region. However, France is almost always facing a higher degree of variability accord-

Figure 7. *PS* distribution by region (average and standard deviation).



ing to the destination. This variability is at its maximum within the Asian countries. More generally, the variability increases with the level of complexity. It is also interesting to underline the results obtained for African destinations: while the phytosanitary requirements are strongly homogeneous *vis à vis* Chile, they are very heterogeneous for France.

The next Figures from 8 to 11 present the relationship between the importers' complexity of phytosanitary constraints and exports. In order to reduce the high trade variability, we aggregate trade volumes by countries sharing similar or identical phytosanitary scores. In the case of France, we are able to distinguish 6 ranges. Conversely, for Chile we only have 5 ranges, because of the strong requirements' homogeneity.

Figure 8 suggests that for France, the level of trade is, as expected, inversely related to the level of complexity in the sanitary requirements of its partner, and reaches zero in the case of a ban (maximum restriction). Figure 9 shows that this result is globally confirmed, even when we eliminate extreme values, such as EU (no restriction) and bans (full restriction).

However, results are quite different for Chile. As Figure 6 shows, the phytosanitary constraints imposed to Chile by its trade partners are particularly homogenous (except for a few countries on the right side of the distribution). This strong homogeneity of the score does not allow us to discriminate between several ranges and therefore correctly test the correlation between trade flow and score value. Therefore, although figures 10 and 11 show a negative and clear correlation between trade and the complexity in phytosanitary regulations (as for France), the results seem more difficult to interpret.

In order to support our argument, we try to provide further analytical details about this topic. If we look at the trade between Chile and North-American countries, we can see that, while the volume of apples from Chile to the USA is important (103,000 tons on average between 2008 and 2013), this is not the case for Mexico (8,000 tons on the same period). The reason has to be found in the stronger demand of Mexican regulations. Yet, although the USA and Chile are located in the same continent (and thus closer in distance), Chile exports more with the EU (347,000 tons in average between 2008 and 2013)

Figure 8. *PS* value by range and volume of French apple export (2007-2013).

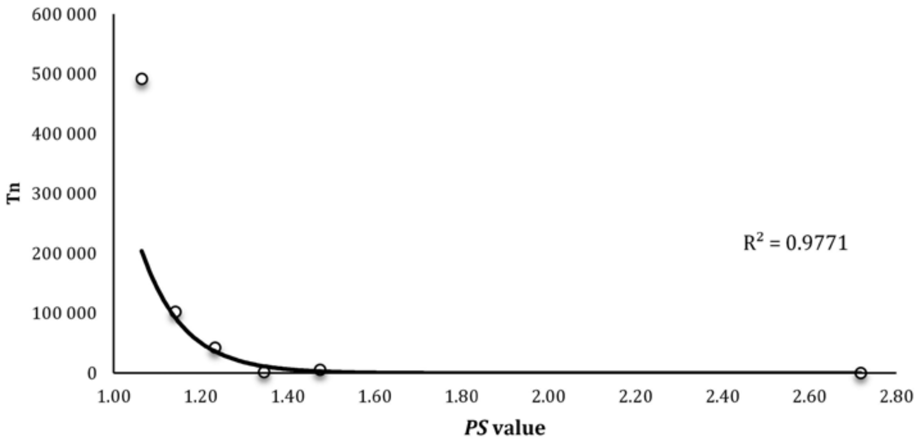
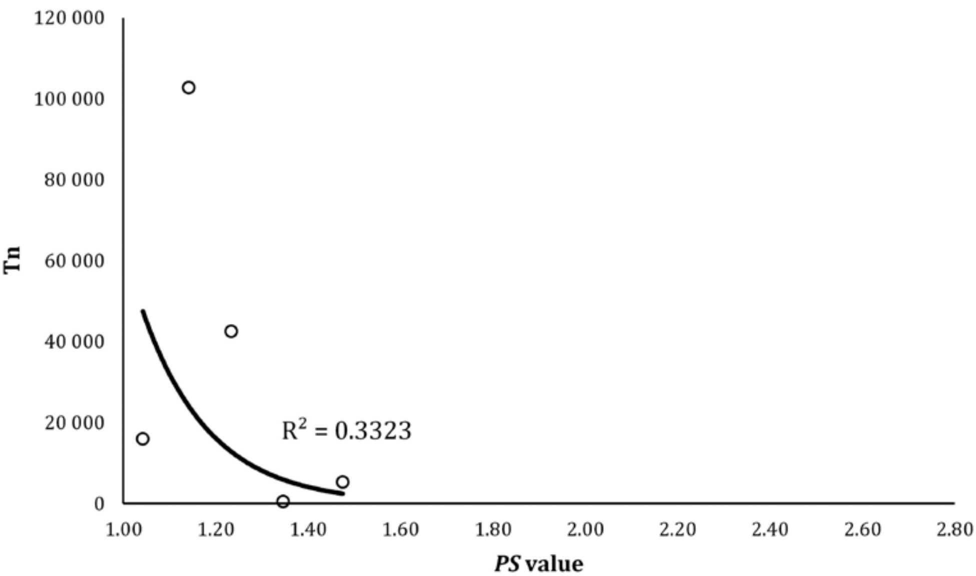


Figure 9. *PS* value by range and volume of French apple export (2007-2013) without EU countries.



than with the USA. We suggest that the cause can also be attributed to the stringency of the US regulations in comparison with those of the EU.

Another explanation could be found in the existence of a trade agreement between the two countries under scrutiny and their trade partners. Table A1 in appendix shows the existence or absence of a trade agreement. The information suggests that for France the geographical proximity and the existence of a trade agreement often overlap and the link

Figure 10. *PS* value by range and average volume of Chile apple export (2007-2013).

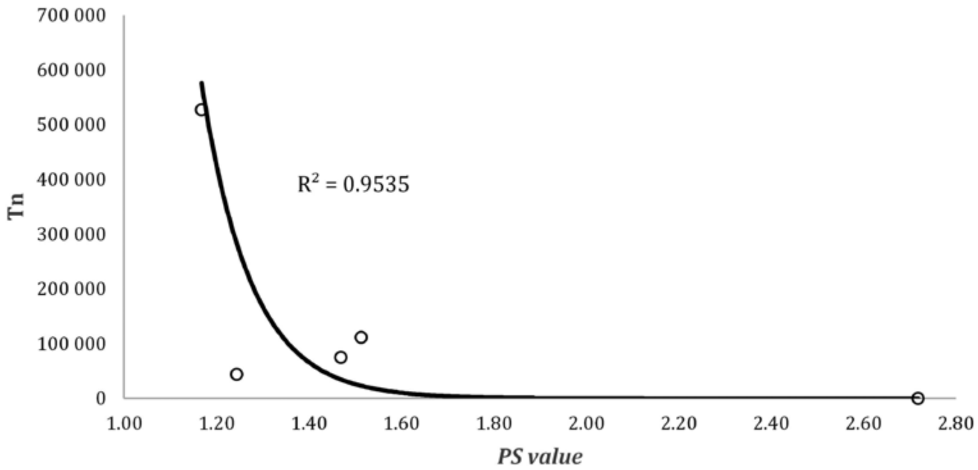
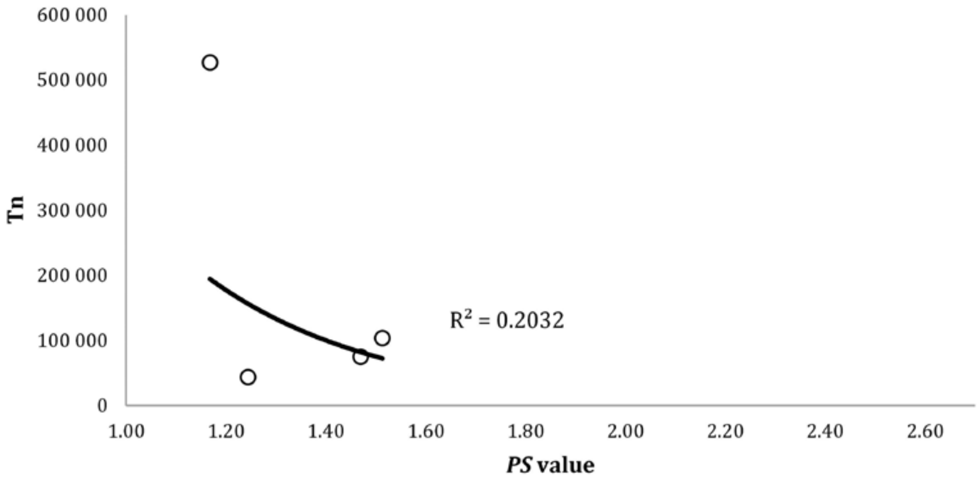


Figure 11. *PS* value by range and average volume of Chile apples export (2007-2013) without USA.



between the existence of the agreement and the level of trade cannot be clearly traced. Moreover, even if the EU (and therefore France) has signed a trade agreement with South Africa, South Korea and Tunisia, French apples are still banned from these countries for phytosanitary reasons.

For Chile, it is slightly different. There is no particular overlapping between the existence of a trade agreement and proximity. But there is also no clear link between the absence of a trade agreement and the absence of trade. Chile exports more apples to Colombia, Ecuador or Peru where no agreement has been signed compared to Brazil with which an agreement has been signed. The same is true when the importer is farer: Chile is able to export high volumes even without the existence of a trade agreement; it is the case with India, Russia, Saudi Arabia, Taiwan or the Arab Emirates (see table A1).

6. Conclusion

For a long time, France has taken the world leadership in the apple international markets. But the French competitiveness is short of breath. French exporters point at the increasing complexity of the phytosanitary rules governing fresh fruits trade, especially in Asia and the USA.

On the other side, Chile, a growing stakeholder in the apple sector has seen its exports increase regardless of the destination. Even if Chile benefit from its off-season supply with respect to its main destinations (USA, Europe, China), it seems generally less sensitive to the phytosanitary restrictions.

Using a synthetic measure, we studied the link between the level of French and Chilean apples exports and the complexity of the phytosanitary requirements imposed by importing countries. Analysing the regulations for more than 130 destinations (84 importing countries for France and 51 for Chile), we were able to draw several conclusions.

First, we observe that no significant difference between phytosanitary restrictions imposed to France and Chile by destinations exists; therefore, the distributions of *PS* in Figures 5 and 6 are rather similar for both exporting countries.

Second, there is no clear link between the existence or absence of a trade agreement between the two countries and their trade partners and their capacity to penetrate a specific market.

Third, we have yet underlined that the French and Chilean positions inside the *PS* distributions is not the same. France belongs to the EU which is less demanding in terms of phytosanitary regulations, while Chile belongs to the group of countries applying more complex phytosanitary regulations (as China, Indonesia, Taiwan, Thailand or the USA). Therefore, this difference in the relative phytosanitary positions of France and Chile with respect to phytosanitary restrictions abroad, allows us to better explain why Chile resists better to more demanding destinations in terms of phytosanitary regulations than France (see Figures 7 to 11).

French exporters suffer higher costs in complying with phytosanitary rules, especially when they are imposed by the most dynamic importing countries (as Asian countries). For instance, French producers must make a greater effort in pest risk management in comparison to the Chilean producers, when they want to export apples free from the Mediterranean fly to China or Taiwan.

As emerging economies increase their consumption of fruits, with the increase in their per capita income, a new demand appears, especially in Asian countries, opening opportunities for apple growers and exporters.

However even if Chile and France face regulations from Asian countries (especially China, Taiwan or India), its geographical location, the off-season nature of its production and its natural phytosanitary conditions (Mediterranean fly free area) give the former an advantage in terms of capacity of compliance. In the Chilean case, as their phytosanitary restrictions are very close to those imposed by Asian countries or USA, it acts as a "common regulatory language". It reduces asymmetries in pest risk management and facilitates trade. Thus, it is possible to understand why Chilean exports to Taiwan or USA coexist with high score value: once the constraints overcome, due to a learning effect or similarities in natural phytosanitary conditions, trade can unlock its potential.

In the French case, phytosanitary restrictions imposed by Asian countries or USA are the translation of really different natural and phytosanitary conditions. Then the regulations imposed to France by third countries act as real barriers with high costs of compliance (and learning).

These results, despite apparently opposed for France and Chile, are both consistent with the economic literature on international trade and non-tariff barriers, and suggest once more that sanitary and technical regulations can facilitate as well as hamper trade causing redistribution in the market shares.

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Appendix

Table A1. PS by country of 20 selected destinations of France and Chile apples.

France				Chile			
Country	PS Value	Trade Average 2007-2013	Existence of a trade agreement	Country	PS VALUE	Trade Average 2007-2013	Existence of a FTA
Algeria	1.16	63,437	Yes	Algeria	1.18	601	No
Angola	1.24	46	No	Bahrain	1.14	1,307	No
Australia	1.22	14	No	Belgium	1.18	5,756	yes
Austria	1.07	614	Yes	Bolivia	1.18	14,974	No
Bahrain	1.24	365	No	Brazil	1.15	13,400	Yes
Bangladesh	1.28	261	No	Canada	1.18	15,548	Yes
Belgium	1.07	37,748	Yes	China	1.47	12,467	Yes
Brazil	1.21	2,049	No	Colombia	1.15	68,894	No
Bulgaria	1.07	16	Yes	Costa Rica	1.14	7,810	Yes
Canada	1.15	422	No	Cyprus	1.18	535	Yes
China	1.47	638	No	Denmark	1.18	1,952	Yes
Colombia	1.28	965	No	Domin. Republic	1.25	1,705	No
Costa Rica	1.24	93	No	Ecuador	1.07	44,748	No
Cote d'Ivoire	1.24	727	No	Egypt	1.18	5,378	No
Czech Republic	1.07	449	No	El Salvador	1.14	4,841	Yes
Denmark	1.07	12,580	Yes	Finland	1.18	1,162	Yes
Djibouti	1.00	24	No	France	1.18	9,452	Yes
Ecuador	1.20	57	No	Georgia	1.18	327	No
Egypt	1.08	1,619	Yes	Germany	1.18	12,456	Yes

France				Chile			
Country	PS Value	Trade Average 2007-2013	Existence of a trade agreement	Country	PS VALUE	Trade Average 2007-2013	Existence of a FTA
Equat. Guinea	1.30	31	No	Greece	1.14	5,028	Yes
Estonia	1.07	318	Yes	Guatemala	1.18	5,403	Yes
Ethiopia	1.24	0.1	No	Honduras	1.22	3,243	No
Finland	1.07	11,745	Yes	Hong Kong	1.18	8,716	No
Germany	1.07	56,902	Yes	India	1.47	20,605	No
Greece	1.07	96	Yes	Ireland	1.18	2,530	Yes
Guinea	1.20	254	No	Italy	1.18	10,135	Yes
Honduras	1.24	0.1	No	Japan	2.72	0	No
Hong Kong	1.00	1,968	No	Jordan	1.30	797	No
Hungary	1.07	54	Yes	Kuwait	1.18	3,740	No
Iceland	1.07	65	Yes	Latvia	1.18	360	Yes
India	1.19	339	No	Libya	1.14	2,568	No
Indonesia	2.72	1,126	No	Malta	1.18	495	Yes
Iran	1.24	1,576	No	Mexico	1.51	8,053	Yes
Ireland	1.07	20,274	Yes	Netherlands	1.18	63,406	Yes
Israel	1.46	1,021	Yes	Norway	1.18	3,990	Yes
Italy	1.07	3,952	Yes	Oman	1.14	1,814	No
Jordan	1.28	213	Yes	Panama	1.19	1991	No
Kazakhstan	1.18	103	Yes	Peru	1.22	38,402	No
Kenya	1.28	199	No	Portugal	1.18	2,978	Yes
Kuwait	1.20	2,226	No	Qatar	1.18	1,193	No
Latvia	1.07	72	Yes	Russia	1.18	38,062	No
Libya	1.20	2,992	No	Saudi Arabia	1.18	49,620	No
Lithuania	1.07	718	Yes	South Korea	2.72	0	Yes
Luxembourg	1.07	1,092	Yes	Spain	1.18	21,593	Yes
Malaysia	1.11	4,885	No	Sweden	1.18	5,573	Yes
Maldives	1.00	276	No	Taiwan	1.47	41,995	No
Malta	1.07	7	Yes	Turkey	1.18	2,266	Yes
Mauritania	1.20	657	No	UAE	1.18	26,322	No
Mayotte	1.07	438	Yes	United Kingdom	1.18	31,919	Yes
Morocco	1.10	914	Yes	USA	1.51	103,697	Yes
N. Caledonia	1.03	163	Yes	Venezuela	1.18	28,416	No
Netherlands	1.07	66,287	Yes				
Nigeria	1.36	3	No				
Norway	1.07	2,279	Yes				
Oman	1.24	2,631	No				
Poland	1.07	644	Yes				
Portugal	1.07	25,520	Yes				
Romania	1.07	78	Yes				
Russia	1.21	26,118	Yes				
Saudi Arabia	1.12	16,631	No				

France			
Country	PS Value	Trade Average 2007-2013	Existence of a trade agreement
Seychelles	1.20	56	No
Singapore	1.09	3,770	No
Slovenia	1.07	36	Yes
South Africa	2.72	40	Yes
South Korea	2.72	0	Yes
Spain	1.07	101,845	Yes
Sri Lanka	1.28	49	No
Sudan	1.24	479	No
Sweden	1.07	9,104	Yes
Switzerland	1.07	643	Yes
Taiwan	1.47	287	No
Thailand	1.45	3,375	No
Togo	1.20	200	No
Tunisia	2.72	18	Yes
Turkey	1.28	204	Yes
United Arab Emirates	1.10	16,033	No
Uganda	1.17	14	No
United Kingdom	1.07	132,141	Yes
Uruguay	1.22	24	No
USA	1.52	25	No
Venezuela	1.22	200	No
VietNam	1.38	120	No

Box A1. SPS requirements description.

1. Ban and Territorial restriction. The ban forbids all exports of a product towards a third country. The ban may be justified either because of the presence of a quarantine organism in the country of origin but in the country of destination, as it is the case in Tunisia or in South Africa for French apples. Furthermore, countries of destination can temporary refuse imports as in the case of the apples from USA in Japan and from France in Vietnam (see above). Territorial restriction/Quarantine organism restriction: the importing country can impose to its providers that goods crossing its borders originate only from specific parts of the country of origin where quarantine organisms are absent or under control. For instance, France has negotiated a protocol with Indonesia which makes sure that only apples from the region «Pays de la Loire» can be exported. China and Taiwan impose similar restrictions to Chile. Area restriction is then an actual trade restriction.
2. Accreditation: is a more advanced form of territorial restriction. For instance, China or Taiwan establishes a precise list of orchards, of storage and packing facilities, of exporters with the domestic sanitary authorities. The list of accredited organisms can be defined in different ways. In the simplest case it is the local authority (in France the SRAL) which compiles the list of producers complying with phytosanitary requisites and the importer only needs to approve or not the list. Or, the importing country may decide to approve the list after the inspection of the producing units by its own inspectors. The frequency of inspections may vary according to what has been agreed upon by both parties.
3. The import permit (IP): this document is required by few countries imposing additional/reinforced inspections of goods. For instance, Israel phytosanitary authorities require that 2% of the total French exports are examined by local authorities (SRAL). Similar requests are addressed to Chile by countries like Honduras or Bolivia. In both cases, it is a more demanding control compared to the one usually performed by national sanitary authorities to deliver the PC. It is for this reason that the results of IP's inspections are quoted in the PC in the box "additional documents".
4. The Phytosanitary Certificate (PC): in the simplest case (as it is the case for France vs. Norway), the PC is obtained after a visual inspection by the SRAL of apples to be exported. Thus, issuing the PC is equivalent to an inspection. In more complex cases, the PC must mention also all the additional inspections required by the importing country and certified by the SRAL (origin of the products, agreement, import permit, cold treatment etc.)
5. Pre-inspection (or internal inspection): is an additional inspection required by a few countries among which USA and Taiwan. It is also qualified as double internal inspection because it must be implemented by the storage/packing employees before and during the packing operations. This double checking must be validated by the national Safety Authority.
6. Pre-clearance is an additional pre-shipment inspection required by the USA. The pre-clearance procedure must be performed by the APHIS/USDA inspectors and APHIS/USDA trained domestic inspectors (from the SRAL). Moreover, the volumes of the sample intended for inspection are defined by the APHIS/USDA regulation and are larger than those usually required by the SRAL (it is the reason why the presence of the SRAL is necessary during the samples' inspection). However, though we have to consider here the pre-clearance as a simple additional inspection, negotiations between USA and Italy or New Zealand show that pre-clearance is a heavier system of export control (2 or 3 inspections) which can coincide in the French case with a mix of pre-inspections and cold treatment.
7. The pre-cooling/fumigation: in case of the presence of the Mediterranean fly in the producing country, some importers require that the exporter prove that before the loading of apples in the refrigerated container, the merchandise has already reached the temperature recommended by the regulation (pre-cold treatment) or has been subjected to fumigation (with Methyl bromide). In this case the exporter requests the national Safety Authority to certify the apples have been subject to fumigation or pre-cooling during the storage and they have reached the temperature needed to start the cold treatment.
8. The cold treatment requires that fruits must be stored at a constant temperature between 0° and 4° for a period of 14 to 21 days to prevent contamination of products by harmful organisms. For all destinations requiring the cold treatment during the transit, the SRAL is requested to inspect and certify all the stages of loading in the refrigerated containers and the position of the sensors. The SRAL certifies the first stage of the process.
9. Inspection at arrival: it is a final and additional (or unique) inspection performed by representatives of the local phytosanitary authority, which sets the volumes of the samples to be inspected.