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CHEESE, SHRIMP AND FLOWERS

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by

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Abstract

This report applies a cost-benefit analysis to quantify the economic effects of non-tariff measures in the agri-food sector. Three case studies are presented to demonstrate how such analysis can help identify least-cost solutions of Non-Trade Measures (NTMs) designed to ensure that imported products meet domestic requirements. The present analysis examines benefits and costs for the different domestic and foreign stakeholders involved, thus taking a broader view that goes beyond evaluating the trade impact alone.

The three case studies focus on mandatory measures implemented by OECD governments. They cover several countries (including some non-OECD) and several sets of issues. The first case study analyses production and import requirements for raw milk cheese in so far as they concern a so-called consumer externality related to human health, specifically contamination with *Listeria monocytogenes*. This externality affects intra-OECD trade, with some countries imposing stricter production and importation requirements, resulting in certain cheese varieties being non-tradable between some countries. The second case study looks into import requirements for shrimps. This again concerns a consumer externality related to human health: the use of antibiotics in shrimp production. The analysis also examines the concerns of foreign suppliers located outside the OECD area (India, Indonesia and Viet Nam) and how they are affected by such NTMs as import bans and free trade in combination with requirements to adopt improved production methods. The third case study on cut flowers concerns a producer externality related to invasive species which can potentially lower the commercial value of the output of domestic producers. The NTM considered here is the stricter border inspection in the European Union, which is of concern to foreign suppliers (Kenya, Israel and Ecuador).

Key words: Trade policy, international trade, non-tariff measures, food safety, plant health

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Executive Summary

Regulations in the food and agriculture sector are put in place and enforced by governments in order to address societal interests where unregulated markets are not yielding the desired outcome. Many of the regulations address human health issues; others address environmental and animal welfare problems associated with agricultural production. Border and behind-the border measures are put in place by governments to assure that the imported varieties meet domestic requirements. Research on non-tariff measures (NTMs) is thus at the interface between domestic regulations and international trade.

There typically are different alternative policy options available to address a given market failure. The first part of the work on NTMs in agri-food trade developed a framework for a systematic accounting of economic costs and benefits of NTMs (OECD, 2009). This framework allows for an economic assessment of the trade-offs among alternative trade-related policies to address the same market failures

This report applies the conceptual cost-benefit framework to three cases, with the objective of checking the feasibility of the approach and identifying areas for future improvements. The cases have been selected using a data-driven approach. This report concentrates on the methodological and data aspects of the cases considered. While providing analyses of the policies considered, it also highlights a number of limitations rendering the empirical results partial and subject to significant uncertainty. In addition, the estimates of changes in the consumer welfare due to the elimination of an entire market segment, as in the first case study on raw milk cheese, strongly depend on details in the model deployed, thus severely limiting the model's ability to properly predict net benefits or benefit-cost ratios of this kind of policy change unless additional data allows the data-based choice of those model details.

The three cases in this report focus on mandatory measures put in place by OECD governments. They cover several countries (including some non-OECD countries) and different sets of issues.

The first case concerns production and import requirements for raw milk cheese. This case concerns a so-called consumer externality relating to human health, specifically contamination with *Listeria monocytogenes* (henceforward referred to as *Listeria*). The trade aspect affects intra-OECD trade, with some countries imposing stricter production and importation requirements than others, which leads to some cheese varieties being non-tradable between those countries. The NTMs considered are import bans on certain varieties of cheese, and alternatively authorization of sales of these varieties.

The second case study looks into import requirements for shrimps. This again concerns a consumer externality related to human health: the use of antibiotics in shrimp production. Concerns of foreign suppliers, located outside the OECD area (India, Indonesia and Viet Nam), constitute an additional dimension of this case study. The

NTMs considered are import bans and free trade in combination with requirements to adopt improved production methods.

The third case is on cut flowers and concerns a producer externality relating to invasive species, which potentially can lower the commercial value of the output of domestic producers. The NTM considered is tighter border inspection, which brings concerns to foreign suppliers from non-OECD countries.

In addition to spanning different countries, different products and different types of externalities, the three cases also employ different variations of the basic cost-benefit framework set out in OECD (2008). The cheese study estimates the willingness to pay to avoid contamination with *Listeria*. The shrimp study examines the cost of compliance with production requirements and the flower case focuses on market access related to the probability of infection and to the probability of detection at the border. The latter also highlights inspection costs. Thus, each of the case studies abstracts from the basic version of the cost-benefit framework. Overall, these case studies show the flexibility of the cost-benefit framework to analyse different types of NTMs, as well as the various possibilities of extending the analysis further. All numerical calculations are done in excel spreadsheets that can be obtained upon request.

The first case study, young raw milk camembert and brie in the Canadian province of Quebec, suggests that the consumption of young raw milk cheese can be costly to both consumers and other agents such as public health care systems and companies, as it brings the risk of *Listeria* diseases. A ban on such cheese varieties, however, could result in significant losses as consumers value the specific taste of those cheeses, thus losing both choice and supplies in the cheese market. This loss tends to be particularly high for consumers with a lower risk of *Listeria* infection. Results of the empirical analysis suggest that in the case of camembert and brie in Quebec these losses might outweigh the reduction of the health risk. But given that a number of factors have not been accounted for – in particular the potential health risk for consumers not belonging to highly concerned groups, the potential presence of other microbiological hazards in raw milk cheese, and the costs to government and industries to enforce product qualtity or in the event of an outbreak of listeriosis – these results ignore a number of potential benefits of banning imports and domestic production (or additional costs in the case of additional domestic raw milk cheese supplies) and can therefore not be taken as final. While, compared to those unaccounted factors, the analysis tends to be fairly robust relative to the main assumptions that were necessary in the absence of detailed estimates of required parameters, the significant dependence of the consumer welfare estimates on the functional form deployed in the demand model indicates an even more serious limitation in applying the methodology for this kind of policy analysis, disallowing conclusions on the sign of overall welfare changes. A richer data set would allow the data-based choice of the functional form, thus potentially avoiding this problem.

The second case study, shrimp imports from South-East Asia to OECD countries, suggests that improved production methods could benefit both producers in the exporting countries through higher profits, and the importing OECD countries given the lower risk of antibiotical residues in the product. Based on the available data, however, a switch to disease resistant but smaller and hence cheaper shrimp varieties seems of little interest to the producers unless the price premium for the bigger but less resistant shrimp varieties is reduced – or cost advantages can be expanded. As in the case of raw milk cheese, however, this analysis rests on assumptions for a number of variables and parameters. While the results tend to be robust with respect to the main parameters, they strongly depend on the estimated change in production costs which themselves are dependent, among others, on structural changes in the shrimp industry. The study also ignores possible effects on small producers who may face greater problems to employ improved production methods.

The final case study, cut flower imports from Kenya, Israel and Ecuador to the EU, suggests that the costs of tighter border inspection and costs due to changes in the production methods tend to be large relative to the gains of avoiding contamination for EU flower producers. Profit losses for foreign producers and, even more significantly, inspection costs at the border are found to be multiples of the avoided contamination costs. If the inspection costs are paid – directly or indirectly throught the importing company – by producers in the exporting countries, they can become prohibitive. The degree of quality deterioration due to extended inspection times, and of price discounts resulting from that deterioration, has major impacts on the size of the profit loss for foreign producers, as does the level of cost increases related to improved production methods lowering the infection risk. The results also depend on the share of import consignments actually being contaminated, a share that is likely to vary across export countries and possibly over time.

Although the above conclusions are offered in terms of economic welfare effects of hypothetical changes in measures, these conclusions should be taken as indicative and interpreted with great care. As noted, the results presented depend crucially on the data used, and herein lays a major challenge for this type of work which is conducted at the very detailed product level. Many of the relevant regulations concern very detailed products, or even varieties of products, and at this level data availability is a problem. The analysis presented here had to rely largely on secondary and published data, as opposed to primary data collected for a specific purpose. Consequently numerous, and sometimes heroic, assumptions had to be made, which have inevitably a bearing on the precision of the analysis and on the validity of the conclusions offered. The report tries to be very explicit about the assumptions made, and discusses the relevance of these assumptions through a number of sensitivity analyses. In this way it hopes to highlight the crucial importance of the availability of good information and data for any cost-benefit analysis of NTMs. In that context, the case studies presented here illustrate how the cost-benefit framework can be used for policy analysis, if the necessary data are available.

The case studies show that the framework as such is flexible enough to accommodate a relatively broad set of issues, but adoptions to the specific circumstances have to be done. None of those adoptions is conceptually very challenging, as they all rest firmly within the familiar partial equilibrium supply-demand analysis, and the associated surplus calculations, but parameterization becomes a challenge if the data are weak. In this case sensitivity analysis on the parameters can help to inform about the robustness of results under ranges of parameter settings, but this is an imperfect substitute for improved parameter estimation.

Part A.

A cost-benefit analysis for the assessment of the authorization of raw milk cheeses

For many centuries cheese was made from raw milk. The origin of cheese predates recorded history, with the first archaeological reference to cheese-making found on Egyptian tomb murals (2000 BC). Homer, in his Odyssey (8th century BC), described the Cyclops making cheese. Pliny the Elder (77) dedicated a chapter of his *Natural History* to the cheeses enjoyed by Romans, mentioning cheeses similar to Roquefort and Cantal. Many of the current best-known cheeses (cheddar, gruyère, beaufort, gorgonzola, parmesan, cheshire…) were developed in the Middle Ages while the famous camembert de Normandie was created in 1791 during the French Revolution.

Following the discovery of the pasteurization process by Pasteur in 1862 and its application to cheese by Duclaux a few years later, the development of large-scale industrial cheese production stared in the 19th century. During World War II, factory cheese, which was overwhelmingly made from pasteurized milk because of the fear of outbreaks of food-borne illness associated with raw milk, overtook traditional cheese making. But raw milk cheeses have never disappeared completely, and a growing number of consumers appreciate the original taste and smell of traditional cheeses. This fondness of raw milk cheese (and possibly a lack of information about potential health risks) has even led to the emergence of a black market in some countries that do not legally allow the sale of such products (Castro, 2005).

The raw milk taste comes at a certain health risk. Some microbiological hazards, such as *Listeria*, *Salmonella*, and *Escherichia coli* may be present in these products. Scientific research on the risk of *listeria monocytogenes* linked to the consumption of raw milk cheese is ongoing and on average across the general population the health risk associated with consuming raw milk products is typically assessed as small. For most people, the consequences of related food-borne infections are not severe. However, there are particularly vulnerable groups of persons for whom the health risk is greater and the consequences more likely to be severe. Those vulnerable groups are young persons, frail elderly persons, pregnant women and persons whose immune system is compromised. For the United States, for example, the incidence of raw milk related cases of *listeriosis* can be estimated at 1.91 cases per million inhabitants. Labelling and education programmes can help to mitigate the risks by enabling this group of vulnerable consumers to avoid consumption of raw milk products, but the risks cannot completely be eliminated.

As knowledge of the risk presented by raw milk cheeses of *Listeria* and other food borne diseases has grown, various regulatory solutions have been adopted that are intended to protect consumers and provide access to cheeses such as camembert and brie.

Some countries have simply insisted that all cheese be made from pasteurized milk and indeed, camembert and brie made from pasteurized milk is available in most countries. It has been thought that risk from *Listeria* normally diminishes over time if the cheeses are stored under appropriate conditions. Some countries, including Canada, the United States, and others, therefore have also allowed the sale of raw milk camembert and brie that have been stored for 60 days under appropriate conditions. In addition, the cheeses have to be tested regularly during this storage period to assure their safety. However, these cheeses have a relatively short period which is considered ideal for consumption: if not stored long enough they are relatively hard; if stored too long, they become too runny. The 60-day storage period may allow sufficient time for domestically produced cheeses to be distributed in or close to this ideal window but is difficult to meet for imported cheeses.

Recently, some countries have begun to consider new legislations, or modifying existing ones, to allow the production and sale of a wider range of raw milk cheeses on their territory. Since July 2001, Canada has provided a special facility to import raw milk cheeses stored for less than 60 days for consumers in the province of Quebec who are especially fond of raw milk cheeses. In August 2008, the Canadian province of Quebec changed the regulations now allowing for all raw milk cheeses of domestic or foreign origin on its market. Australia is undertaking an assessment to determine whether the processing requirements can be amended to allow a greater range of raw milk products without compromising public health and safety. New Zealand has introduced a new regulatory framework that is also expected to extend the list of raw milk cheeses sold in its territory.

These recent changes in regulations, and potential future ones, raise the issue of the impact of market liberalization on cheese consumers, cheese producers and food safety authorities. This report provides an economic assessment of market liberalization and greater openness to raw milk cheeses. It concentrates on the effects on the supply chain and on consumers, but does not provide a full quantitative assessment of regulatory costs. It also does not include additional costs of compliance that producers would have to bear if raw milk cheese production were allowed under strict production protocols that did not exist before. Given its economic focus, this report does not provide a full microbilogical risk assessment, including the impact of varying phyiso-chemical properties of cheeses which will impact on the survival of pathogens. These limitations render the welfare analysis partial, and the results have to be interpreted accordingly.

Part A focuses on *Listeria*, which is only one of a number of pathogens which can be present in raw milk but are generally destroyed through pasteurization[1]. Other relevant pathogens include *Campylobacter spp*., *Escherichia coli (E. coli)*, and *Salmonella serovars*, and each is capable of causing significant human illness. The analysis focuses on the Canadian cheese market – more specifically: the market for camembert and brie cheese in Quebec – while in addition looking at regulations on raw milk cheese markets in three other countries: the United States, Australia, and New Zealand. Within this group, alternative ways of regulating the sale of raw milk cheeses can be observed. Canada and the United States permit sales of raw milk cheeses aged at least 60 days, while the regulations in Australia generally forbid sales of such products, but make exemptions for very limited number of raw milk cheeses (emmental, gruyere, sbrinz, roquefort, and extra-hard cheeses). In New Zealand, raw milk cheeses which support the

1. The risk of indirect contamination, which can affect both products from raw and from pasteurized milk, is not considered here.

growth of pathogens to levels in excess of food safety criteria are not permitted for sale. Trade restrictions for health and safety reasons are allowed under the WTO Sanitary and Phytosanitary (SPS) Agreement, provided such restrictions are based on scientific risk assessments.

The present analysis concentrates on two raw milk cheeses: camembert and brie. Sales of these cheeses if stored for less than 60 days ("young raw milk cheese") have until recently been almost completely forbidden in the four countries, with an exception for imports from France to Canada since 2001. Since August 2008, the Canadian province Quebec allows sales of both varieties from both domestic production and imports. The data available on Quebec are limited but allow some inference of demand for young raw milk camembert and brie after relaxation of the regulations. The intrinsic characteristics of brie and camembert cheeses – in particular their high moisture content and the relatively low age when consumed – and the processing techniques that they undergo, mean they are likely to pose higher risks to vulnerable consumers than many other young raw milk cheeses and consequently their production may be subject to more extensive regulatory controls. Therefore, some of the findings of the cost-benefit analysis may be specific to these two varieties and may not be entirely relevant to all young raw milk cheeses.

Welfare changes are estimated through a cost-benefit analysis, following the approach outlined in OECD (2008). This provides a framework for a systematic accounting of economic costs and benefits associated with each authorization regime (ban or approval). We compare the actual situation in 2006, which allows for French imports of raw milk cheese stored for less than 60 days, to a counterfactual scenario assuming a ban for such young raw milk cheese imports, reflecting the legal situation in Canada before 2001. The framework incorporates two types of cheeses, young raw milk and pasteurized (including aged raw milk) cheese, and two main types of consumers: those who belong to highly vulnerable groups and those who do not. The vulnerable group is further divided into informed persons about health risks associated with raw milk cheeses, and persons that are not informed about the health risks. The costs of authorization are assessed by including a measure of consumers' willingness to pay for avoidance of risk. The benefits of authorization arise mainly through greater product variety. Cross-market effects on the pasteurized segment arising from the allowance of young raw milk cheeses are also taken into account.

Part A is structured as follows. The next section briefly describes the regulations for the sale of raw milk cheeses in Canada, the United States, Australia, and New Zealand, and provides some facts about demand, production and imports of such products in some of these countries. Section A3 develops the cost-benefit framework for the assessment of the authorization of young raw milk cheeses. Data and calibration are presented in Section A4. Section A5 presents the results, while section A6 concludes. Analytical detail is presented in an appendix. All calculations are performed in a spreadsheet that can be obtained upon request.

A1. The regulatory context

The United States

The United States federal regulation (21CFR133)[2] allows cheeses to be pasteurized or to be unpasteurized, as long as in the second case they have been aged at least 60 days in an environment held at a temperature not less than 35 degrees Fahrenheit (1.7 degree Celsius). During the ageing process, the cheese acidity increases and most potential sources of bacterial infection are killed. In each state, cheeses are generally regulated under the state's dairy manufacturing laws. However, all states allow the sale of raw milk cheeses aged over 60 days, a duration of ageing beyond which "no outbreak has been reported…" (Knoll, 2005).

Canada

Regulation of production and sale is a responsibility of both provincial and federal governments. The federal government alone is responsible for regulation of imports and exports. Similarly to the United States, sales of raw milk cheeses are permitted under federal regulation in Canada subject to storage conditions. Prior to sale, cheeses must have been stored at a temperature of 2° Celsius or more for at least 60 days from the date of the beginning of the manufacturing process.[3] French cheeses are exempt from the 60-day rule due to an agreement between the Canadian Food Inspection Agency (CFIA) and the French authorities, which allows the export of French raw milk soft and semi-soft cheeses to Canada. According to the CFIA Dairy Products inspection manual, "as of July 2001, France has provided the CFIA with export certificates for all shipments of these cheeses." These certificates confirm that the product is from a recognized establishment, that the establishment performs microbiological self-testing of their production and has had official sampling and analyses of its product within the last three months. Instead of requiring the 60-day storage period for raw soft and semi-soft cheeses from France, the CFIA accepts receipt of France's certificate for each exported shipment of raw, soft and semi-soft cheeses, together with ongoing microbiological monitoring. Furthermore, Canada is developing a new policy to address the issues related to the regulation of soft and semi-soft cheeses and a Code of Hygienic Practice has been developed by Health Canada, in collaboration with the Canadian Food Inspection Agency and the Quebec Provincial Government. Comments from provincial and territorial governments were requested. Education campaigns, aimed at raising public awareness of the potential hazards associated with raw milk soft and semi-soft cheeses were also launched. On 30 July 2008, Quebec withdrew the 60-day storage period and legalised the production and sale of all raw milk cheeses together with a number of additional production standards to minimize risks.

2. US FDA Code of Federal Regulations (CFR), Title 21 "Food and Drugs", Part 133 "Cheeses and related cheeses products" is available at http://www.access.gpo.gov/nara/cfr/waisidx_00/21cfr133_00.html

3. See the Consolidated Regulations of Canada (CRC), Food and Drugs Regulations, Part B (Food), Division 8 (Dairy Products), Regulation B.08.030 and following available at http://www.canlii.org/ca/regl/crc870/

An outbreak of listeriosis in September 2008 was linked to two traditional cheese producers and 11 cheeses, causing serious injuries and problems of pregnancies. This may have contributed to the observed decline in the consumption of both raw milk and pasteurized cheeses in recent years.

Australia

Australian legislation[4] requires cheeses sold in Australia to be:

- made from pasteurized milk (or equivalent process);
- made from thermised milk and stored at a temperature of no less than 2°C and during 90 days from the date of processing;
- extra-hard, *i.e.* with a curd heated to a temperature of no less than 48°C, and a moisture content of less than 36%, after being stored at no less than 10°C for at least six months from the date of processing.
- Raw-milk emmental, gruyere, sbrinz and roquefort5. emmental, gruyere, sbrinz should be made according to the Swiss regulations and Roquefort according to the French ones. Furthermore, three other requirements are imposed on Roquefort by Australian authorities: (i) pH, salt and moisture should be monitored and recorded during the manufacture, (ii) listeria monocytogenes should not have been detected in the milk used for the production, and (iii) cheese must be stored at least during 90 days from the date of manufacture.

Permission for specific raw milk cheeses in Australia (*e.g.* very hard grating cheese, French roquefort cheese, Swiss emmental, gruyere and sbrinz cheeses) were included in the Food Standards Code following specific applications to FSNAZ. Scientific evaluations were undertaken for each application, which concluded that a low level of public health risk was presented by these cheeses given appropriate controls on the farm and in processing.

Conservative estimates suggest that about 118 tonnes of roquefort, 90 tonnes of the Swiss cheese, and 400 tonnes of the extra-hard grating cheeses are imported annually into Australia (FSANZ, 2008).

In August 2008, Australia made proposals to assess its legislation on production and sale of raw milk products (FSANZ, 2008). The main objectives are to:

- Determine whether the processing requirements currently mandated for milk and dairy products can be made less restrictive, which may allow for a greater availability of raw milk products, while protecting public health and safety;
- Harmonize requirements for imports and domestic production, as imports of some raw milk cheeses are currently allowed but not their domestic production;

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4. Clause 16 of the Standard 4.2.4 “Primary Production and Processing Standard for Dairy Products” (chapter 4 of the Australia New Zealand Food Standards Code available at http://www.foodstandards.gov.au/_srcfiles/Standard_4_2_4_Dairy_PPP_v101.pdf

5. Clause 1 of standard 4.2.4A “Primary Production and Processing Standard for Specific Cheeses” specifies requirements for these four raw milk cheeses. http://www.foodstandards.gov.au/_srcfiles/Standard_4_2_4A_Spec_cheeses_PPP_v101.pdf

- Establish own regulations without reference to foreign legislations for imported cheeses;
- Comply with the WTO SPS and TBT agreements.

When assessing the regulations Australia and New Zealand have to take into account the legislation of the partner country, since according to the Trans-Tasman Mutual Recognition Agreement (TTMRA),[6] raw milk products sold in Australia may also be sold in New Zealand and vice versa.

FSANZ's proposals, like New Zealand's new legislation, are based on a category framework approach. Instead of case-by-case assessments, raw milk products would be classified into three categories according to their food safety risk to human health. The criterion used to define these categories is the impact that "production methods and intrinsic characteristics of the final products have on pathogen survival and growth" (FSANZ, 2008). This impact is evaluated using results of previous and new risk assessments. These new assessments will be based on microbiological surveillance data, epidemiological data, consumption data and existing published and unpublished risk assessments from a variety of sources[7]. They will also identify where in the supply chain hazards may be introduced and whether controls can be implemented to address the hazards and thereby mitigate risk. Intrinsic characteristics could include moisture content, pH, and salt concentrations.

Category 1 would include raw milk products in which pathogens are eliminated (for example extra-hard grating cheeses). These products pose a low risk to consumers, similar to pasteurized and thermised products. Category 2 would consist of products where the intrinsic characteristics and/or processing techniques may allow the survival of pathogens that may have been present in the raw milk but do not support the growth of these pathogens (for example, Roquefort).

Category 3 would contain products that may support the survival and growth of pathogens that may have been present in the raw milk (for example, high moisture content cheeses). These products have been determined to pose too high a public health risk and would therefore not be permitted in Australia.

New Zealand

New Zealand's legislation is similar to that being proposed for Australia by FSANZ and also has a three category framework. Under the the Food (Imported Milk and Milk Products) Standard 2009,[8] made pursuant to the Food Act 1981, milk and milk products imported into New Zealand can be processed using pasteurization or an approved alternative processing method. Imports of raw milk emmental, gruyere and sbrinz cheeses

6. Since May 1998, Australia and New Zealand are linked by the Trans-Tasman Mutual Recognition Agreement (TTMRA), which purpose is to facilitate bilateral trade. Except in a few cases, goods authorized for sale in one country may also be sold in the other one, regardless of any differences in standards or other sales-related regulatory requirements. The caveat remains that all biosecurity requirements must be met.

7 FSANZ has undertaken three microbiological risk assessments (raw cow milk, raw goat milk and raw milk cheeses) to inform the FSANZ Raw Milk Products Proposal.

8. http://www.nzfsa.govt.nz/policy-law/legislation/food-standards/final-import-standard-final-.pdf

originating from Switzerland are also allowed, provided they are produced according to the relevant Swiss sanitary standard. Milk and milk products such as roquefort and extra hard grating cheeses produced in a member state of the European Union can also be imported, provided thay are produced according to the relevant EU sanitary standard.[9] In addition, there is provision for imports of other milk and milk products (including products made from raw milk) to be permitted if they have been manufactured in accordance with an approved overseas sanitary standard that ensures that the manufactured milk or milk product achieves at least an equivalent level of safety protection for consumers as that which is achieved under New Zealand law. The regulatory framework allows for the domestic production and sale of raw milk products which do not support the growth of pathogens to levels in excess of food safety criteria. Domestic producers of such raw milk products must meet legal requirements relating to on-farm practices and processing techniques.[10]

A2. United States and Canadian documents related to listeria

Several official documents dealing with *Listeria* were recently published by national authorities. We briefly mention US and Canadian documents.

In 2003, the Food and Drug Administration's Center for Food Safety and Applied Nutrition conducted, in collaboration with the US Department of Agriculture's Food Safety and Inspection Service and in consultation with the Department of Health and Human Service's Centers for Disease Control and Prevention (CDC), a risk assessment to examine systematically the available scientific data and information to estimate the relative risks of serious illness and death associated with consumption of different types of ready-to-eat foods that may be contaminated with listeria monocytogenes.[11]

Following the 2008 listeriosis outbreak in Canada related to ready-to-eat meat products, Health Canada published a review of its response to identify the strengths, but also strategic area of improvements.[12] Two previous documents on *Listeria* in Canada were published respectively in 1996 and 2004. The first one published by Farber *et al.* (1996) in *Food microbiology* discusses the major steps used in the formulation of a health risk assessment for *Listeria* in foods. The second document published by Health Canada in 2004 provides a guidance regarding the inspection and compliance action of ready-to-eat foods with the respect to their potential to support growth of listeria monocytogenes.[13]

As the government agency responsible for establishing policies and standard setting for the safety and nutritional quality of food sold in Canada, Health Canada has also developed a decision-making framework for identifying, assessing and managing health risks. The approach of Health Canada takes into account the complex interactions

9. The products have to comply with the relevant European Commission (EC) Regulations, notably 852/2004, 853/2004, 854/2004, and any subsequent regulations or amendments that replace or amend any of those regulations.

10. Animal Products (Raw Milk Products Specifications) Notice 2009, http://www.nzfsa.govt.nz/dairy/publications/specifications/final-raw milk-spec.pdf

11. http://www.foodsafety.gov/~dms/lmr2-toc.html

12. http://www.hc-sc.gc.ca/fn-an/pubs/securit/listeriosis-eng.php

13. http://www.hc-sc.gc.ca/fn-an/legislation/pol/policy_listeria_monocytogenes_politique_toc-eng.php

between physical and social environments together with personal and life style choices. The framework consists of three components – issue identification, risk assessment and risk management. While the cost-benefit analysis may be a part of it, the approach of Health Canada is much broader and takes into account epidemiological investigations, toxicology and microbiological studies, and many other factors related to the health risks.[14]

A3. A simple model

To assess the economic impact of changes in regulations concerning young raw milk cheese,[15] the case study employs a relatively simple model that follows the approach outlined in OECD (2008). The model will be calibrated to data from Canada in 2006. Each specific cheese can be made from pasteurized or raw milk. Depending on the regulatory choice, these two varieties of the same specific cheese could therefore be present or absent on the market. The model and all analytical expressions are detailed in Appendix A1.

Figure A1 shows the general set-up of the model used for this analysis. In the base situation (2006), both PORM[16] (q_p^0) and young raw milk cheese (q_r^0) are available on the market, with D and S representing total demand and supply. Demand comes from three different consumer groups: first, those not concerned by *Listeria*; second, those concerned but not informed; and third, those concerned and informed. On the other hand, supply is shared between domestic production (for pasteurized cheese) and imports (for both pasteurized and young raw milk cheese), with imports representing a share of σ in total supplies (*i.e.* $\sigma = 1$ in the case of young raw milk cheese). Within supply, retailers capture a share of ρ of the total value-added. Markets are cleared at p_p^0 and p_r^0, respectively.

A ban of young raw milk cheese (the legal situation before 2001) will have either or both of two effects on cheese demand. The first is a contraction effect: the loss of one of the varieties may reduce the total consumption of cheese. The second is a substitution effect: the unavailability of one variety may expand the demand for other cheese. Hence, both supply and demand of young raw milk cheese shrink to zero, which is equivalent to a (large) sales tax on the product (with the obvious difference that there are no tax revenues for the government). In consequence, consumers lose a consumer surplus equivalent to the area left of D_r and above p_r^0. At the same time, D_p shifts right to D_p', and the equilibrium price for PORM cheese moves up to reach p_p^1. This price change causes

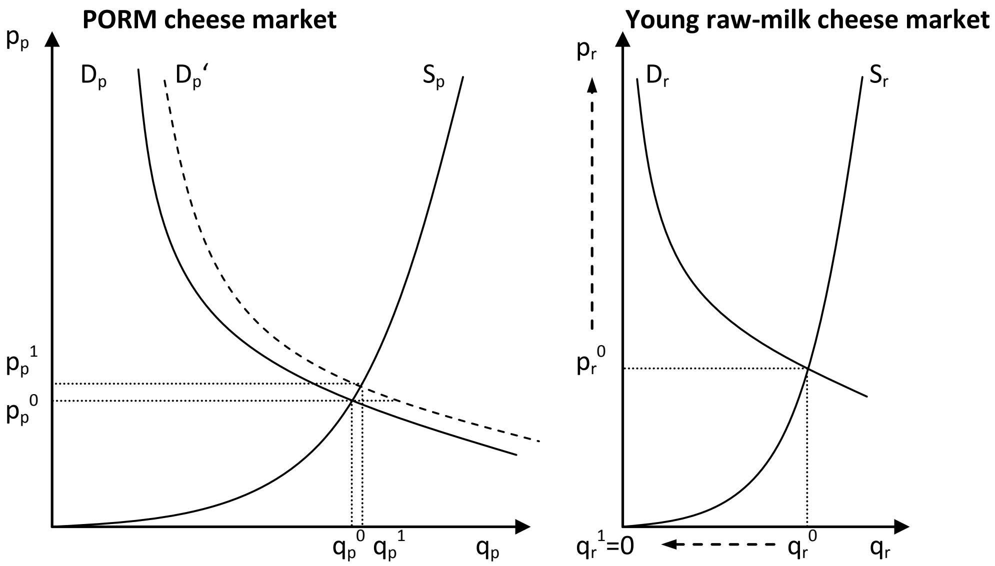
14. The full document is available on the Health Canada website: http://www.hc-sc.gc.ca/ahc-asc/pubs/hpfb-dgpsa/risk-risques_tc-tm-eng.php. To provide guidance to departments and agencies on how to conduct a sound cost benefit analysis, Treasury Board Secretariat of Canada has prepared a document *Canadian Cost-Benefit Analysis Guide: Regulatory Proposal* which can be found at http://www.regulation.gc.ca/documents/gl-ld/analys/analys01-eng.asp.

15. In the following, we will use the term "young raw milk cheese" limited to cheese stored for less than 60 days, *i.e.* to those cheeses available on the market only since 2001. We use the acronym "PORM cheese" to refer to pasteurized and older raw milk cheese (*i.e.* raw milk cheeses stored for at least 60 days), *i.e.* including all cheeses available on the market before 2001.

16. See footnote 17.

consumers to also lose the area left of the new demand curve D_p' and between the two prices p_p^0 and p_p^1.[17]

Figure A1. Market equilibrium with and without young raw milk cheese



Given that there is a health risk associated with the consumption of young raw milk cheese that only a part of the concerned consumers incorporates into their consumption decisions, the concerned consumers who are not informed face some gain that partially compensates for the loss in consumer surplus arising from the ban. This gain is equal to the unit damage of the consumption of young raw milk cheese times the quantity consumed by that group of consumers. The gain represents the avoidance of a loss that is related to those consumers' lack of information. The perceived unit damage is estimated by the willingness to pay for *Listeria*-free cheese.

However, not all costs related to the risk of young raw milk cheese consumption are captured by this willingness to pay, as it likely includes only personal costs of food borne illness such as loss of income and the discomfort of being sick, but does not include societal costs such as treatment costs in public health care jurisdictions or companies' loss in work time. These costs therefore need to be considered separately: the ban of young raw milk cheese would result in a gain equivalent to those costs.

Finally, the effect of such a ban on producers can be calculated by the impact on total profits: while producers of raw milk cheese (in exporting France) lose all the profits related to the Canadian market (*i.e.* the area left of S_r and below p_r^0, shared between foreign producers and retailers, producers of PORM cheese (both domestic and foreign) as well as retailers gain the area left of Sp and between the two prices p_p^0 and p_p^1 from the price increase for PORM cheese.

The impact of the young raw milk cheese ban on domestic welfare can then be calculated by summing up the change in consumer surplus (considering the elimination of

17. The path dependency problem in the calculation of consumer surplus changes in two markets will be discussed further below.

the costs of the lack of information for uninformed but concerned consumers), the elimination of the societal costs, and the change in profits for domestic producers and retailers. Total welfare changes additionally include the change in foreign producers' profits.

A4. Data and calibration

Calculations are made with 2006 data. This section describes in detail the data used for the quantitative analysis for Canada.

Data for Quebec

Quantities of camembert and brie consumed in Quebec

The calculation of base quantities for camembert and brie is outlined in Table A1. Assuming that there are no exports or stocks of camembert and brie, the consumption is the sum of domestic production and imports. The quantities of camembert and brie produced in Canada are not directly available. In its annual statistics on the dairy industry,[18] Agriculture and Agri-Food Canada provides the total cheese production and detailed statistics only for main cheeses.

Detailed figures exist for Canadian imports of camembert and brie and are reported in Agriculture and Agri-Food Canada in its dairy industry statistics. camembert represented 1.78% and brie 6.83% of Canadian cheese imports in 2006.

To estimate the quantities of camembert and brie produced in Canada, it is assumed that the shares of camembert and brie in Canadian cheese production are equal to their shares in Canadian imports. Total consumption of camembert and brie then are estimated at 7 241 036 kg and 27 924 816 kg, respectively.

These totals need to be broken down both by origin (imports versus domestically produced) and by quality (*i.e.* pasteurized and raw milk cheese stored for 60 days or more, representing qualities available to Canadian consumers before 2001; and raw milk cheese stored for less than 60 days, representing qualities available to Canadian consumers only after 2001). Agriculture and Agri-Food Canada (AAFC) provided data on camembert and brie imports which for 2006 were at 394.743 kg and 1 516 572 kg, respectively. Subtracting these figures from total consumption gives estimates for domestic production of camembert and brie at 6 879 188 kg and 26 429 308 kg, respectively.

18. http://www.dairyinfo.gc.ca/index_e.php?s1=dff-fcil&s2=proc-trans&s3=psdp-pvpl&page=prod.

Table A1. Calculation of base quantities for camembert and brie in Quebec, 2006

Row	Variable		Unit	Camembert	Brie	Source
1	Canadian Cheese Production (2006), all cheeses		kg	386 937 000		Agriculture and Agri-Food Canada
1b	Canadian Cheese Imports (2006), all cheeses		kg	22 203 300		Agriculture and Agri-Food Canada
1c	Import share in Canadian Cheese supply (2006), all cheeses		share	5,43%		Row 1b/(row 1+row 1b)
2	C/B imports (2006)		kg	394 743	1 516 572	Agriculture and Agri-Food Canada
3	C/B exports (2006)		kg	0	0	assumption
4	C/B stock changes (2006)		kg	0	0	assumption
5	C/B shares of total cheese imports		share	1,78%	6,83%	2 / 1b
5b	C/B shares of domestic cheese production		share	1,78%	6,83%	assumed = row 5
6	Domestic C/B production		kg	6 879 188	26 429 308	est., row 5b*row 1
7	Domestic C/B consumption (=supply)		kg	7 273 931	27 945 880	est., row 6+row 2
8	Raw milk share of C/B labels, Nov/Dec. 2008		share	16,67%	2,78%	Label count
9	Pastorized share of labels		share	83,33%	97,22%	1 - row 8
10	Domestic consumption (= supply) of pastorized C/B		kg	6 061 609	27 169 605	est., row 9*row 7
11	Import share in each cheese type		share	5,43%	5,43%	assumed = row 1c
12	Imported pasteurized C/B		kg	328 953	1 474 445	est., row 11*row 10
13	Domestic pasteurized C/B		kg	5 732 657	25 695 160	est., row 10-row 12
14	Domestic consumption (= supply) of raw milk C/B		kg	1 212 322	776 274	est., row 7-row 10
15	Imported raw milk C/B		kg	65 791	42 127	est., row 11*row 14
16	Domestic raw milk C/B		kg	1 146 531	734 147	est., row 14-row 15
17	Share of imports >= 60 days stored		share	50%	50%	assumption
18	Imported raw milk C/B, >= 60 days stored		kg	32 895	21 064	est., row 17*row 16
19	Imported raw milk C/B, < 60 days stored		kg	32 895	21 064	est., row 16-row 18
	Pasteurised and raw milk >= 60 days stored, Quebec					
	Quebec share in Canadian pasteurised C/B market			50%	50%	assumed
	domestic production		kg	3 439 594	13 214 654	Row 13+row 16
	imports		kg	180 924	747 754	Row 12+row 18
	domestic consumption	Q_p^0	kg	3 620 518	13 962 408	Row 14
	Raw milk < 60 days stored, Quebec					
	domestic production		kg	0	0	Legislation
	imports		kg	32 895	21 064	row 19
	domestic consumption	Q_r^0	kg	32 895	21 064	row 19

C/B denotes camembert and brie.

Sources: Canadian Dairy Information Center (http://www.dairyinfo.gc.ca/index_e.php?s1=dff-fcil&s2=proc-trans&s3=psdp-pvpl&page=prod and http://www.dairyinfo.gc.ca/pdf/imports_exports.pdf), AAFC bilateral communication of Canadian trade data.

Market share of raw milk cheese

Data on this market share are unavailable. The market share of raw milk cheese is therefore estimated by the number of varieties sold by the IGA online grocery store: 3 out of the 18 varieties of camembert offered by IGA in late 2008 were found to be made of raw milk, whereas this was the case for only one out of 36 varieties of brie. We use these label counts to roughly estimate the market shares of raw milk cheese. Domestic consumption of raw milk camembert and brie in 2006 is hence estimated at 1 212 322 kg and 776 274 kg, respectively. Assuming the same import shares for these groups as for total cheese (5.43%) yields import quantities for raw milk camembert and brie at 65 791 kg and 42 127 kg, respectively. It should be noted that this estimate may underestimate actual raw milk cheese consumption as raw milk cheeses are more likely to be sold in specialized "deli" stores.

No information is available on the storage period of the raw milk cheese. We assume that 50% of the imported raw milk cheese is stored for less than 60 days, yielding import quantities for these particular qualities at 32 895 kg and 21 064 kg. Given that there was no domestic production of such qualities in 2006, these last figures represent the base quantities Q_r^0 used in the model. Given that young raw milk cheese is not available in other provinces, all these quantities were consumed in the province of Quebec. Subtracting them from domestic consumption of camembert and brie yields the Canadian totals of pasteurized and raw milk cheese stored for 60 days and more, *i.e.* authorized before 2001 (7 241 036 kg and 27 924 816 kg, respectively). To calculate the base quantities Q_p^0 for Quebec, these quantities need to be split between that and other provinces. According to Statistics Canada, Quebec accounted for 23.4% of the Canadian population, while Dairy Farmers of Canada estimate the Quebec share of Canadian cheese consumption at 27.1%. They also note, however, the differences in the composition of cheese sales across provinces, indicating brie and camembert to be the most popular cheese categories in Quebec while other cheeses were most popular in the remaining provinces. This suggests that the share of Quebec in the Canadian consumption of camembert and brie is much higher than that in total cheese consumption. We therefore assume a share of 50% for the markets for pasteurized and longer-stored raw milk camembert and brie, yielding base quantities of 3 439 594 kg and 13 214 654 kg, respectively.

Foreign production shares (σ)

This share is obtained by dividing the import volume by the sum of domestic production and imports. Assuming national shares to be representative for Quebec as well, we obtain import shares for PORM camembert and brie at 5.0% and 5.4%, respectively, whereas the import shares for raw milk camembert and brie stored for less than 60 days by regulation were 100%.

Average prices of PORM camembert and brie sold in Canada (p_p)

The estimate of the retail prices of PORM camembert and brie in Canada is based on the prices charged by online groceries. The IGA brand, one of the biggest supermarket chains in Canada, offers an extensive variety of cheeses on its online grocery store (718 specialty cheeses and 345 packaged cheeses) [19]. The prices of pasteurized and raw milk cheeses found on the IGA website are used to calculate simple averages. Cheeses used in the calculation had to satisfy the following criteria: (i) The word “camembert” (or brie) appears in the cheese name or on the picture; (ii) a picture is available; (iii) A cheese is classified as “pasteurized cheese” except if the label “raw milk” is mentioned in the cheese name or on the picture; (iv) the cheese is made from cow milk. This yields a total of 18 camembert varieties, 15 of which are pasteurized and 3 are made with raw milk. For brie, these numbers for 36 brie varieties are 35 are pasteurized and 1 is non-pasteurized.

Calculation of p_p:

Average price of pasteurized camembert: CAD 33.64 /kg

Average price of pasteurized brie: CAD 33.19 / kg

[This amounts to approximately EUR 20/kg.]

We assume these prices to be representative in Quebec for all qualities authorized before 2001, *i.e.* including raw milk cheese stored for 60 days or more. The prices and the quantities of pasteurized cheeses (including raw milk cheese stored for 60 days or more, p_p nd q_p) are affected by market openness to raw milk cheeses. In other words, a change in the availability of raw milk cheese stored for less than 60 days will result in changes in

19. http://magasin.iga.net/Browse/Dairyproducts.aspx. Last checked on 23 January 2009.

p_p and q_p. The observed prices and quantities are also influenced by trade policies. Cheese imports into Canada occur under Tariff Rate Quotas, which may affect price formation depending on quota fill rates and in-quota tariff rates. These factors are not taken into account in the current estimations.

Average prices of young raw milk camembert and brie sold in Canada

Again, this is based on the prices charged by the IGA online grocery, bearing in mind the caveat noted above that raw milk cheese is more likely to be sold in specialized "deli" stores, and that average raw milk cheese prices found at IGA might therefore underestimate actual price levels. Similar to p_p, p_r is calculated as the average of the prices (in CAD/kg) of all raw milk camembert (and brie) sold on the IGA website.

Calculation of p_r:

Average price of raw milk camembert: 39.60 CAD/kg

Average price of raw milk brie: 57.30 CAD/kg

We assume these prices to be representative for raw milk cheese in Quebec stored for less than 60 days.

Demand elasticity (ε)

Demand elasticities for cheese can be found in various databases of large commodity models, such as the Food and Agricultural Policy Research Institute (FAPRI) website[20] or the Aglink database. These two sources give the own-price elasticities for cheese demand at -0.23 and -0.93, respectively.[21] However, neither source differentiates between cheese varieties, and given the substitution between different varieties as well as the different uses across varieties, demand for individual cheese varieties can be expected to be more price elastic than that for aggregate cheese, and demand for specialities such as camembert and brie may be more elastic than that for lower-value varieties used, say, to dress a pizza.

We therefore assume the price elasticities of demand for camembert and brie to be equal to -1.

Substitution elasticity among young raw milk cheese and PORM cheese (γ)

The parameter γ represents the elasticity of substitution between raw milk (stored less than 60 days) and pasteurised cheeses (including raw milk cheeses stored at least 60 days). If γ equals 0, the two qualities of cheese are consumed in fixed proportions irrespective of the prices, whereas a γ approaching infinity would imply the two qualities to be perfect substitute, disallowing the price ratio deviating from its given value. As parameters at that level of detail are unavailable, we assume the elasticity of substitution to be equal to 1.2, *i.e.* slightly higher in absolute terms than the price elasticities of total demand for camembert and brie. We will subject the elasticity of substitution to sensitivity analyses presented below.

These two parameters, together with the required symmetry between cross-price elasticities, allows the calculation of both own- and cross-price elasticities for the two sets

20. http://www.fapri.iastate.edu/tools/elasticity.aspx.

21. Note that the two parameters relate to different prices (producer and retail price, respectively) and therefore are not directly comparable.

of products considered for camembert and brie, *i.e.* the elasticities of demand for pasteurized cheese (including raw milk cheese stored for 60 days or more) and raw milk cheese (stored for less than 60 days) relative to the two price for these qualities. The resulting parameters are presented in Table A2.[22]

Table A2. Demand elaεsticities calculated for camembert and brie in Quebec

		Camembert	Brie
Price elasticity of C/B demand	ε	-1,0000	-1,0000
Elasticity of substitution PORM versus young raw milk C/B	γ	-1,2000	-1,2000
Own-price elastictity of demand for PORM cheese	$\varepsilon_{pp}{}^{d}$	-1,0021	-1,0005
Elasticity of demand for PORM cheese with respect to the price of young raw-milk cheese	$\varepsilon_{pr}{}^{d}$	0,0021	0,0005
Elasticity of demand for young raw-milk cheese with respect to the price of PORM cheese	$\varepsilon_{rp}{}^{d}$	0,1979	0,1995
Own-price elastictity of demand for young raw milk cheese	$\varepsilon_{rr}{}^{d}$	-1,1979	-1,1995

C/B: camembert/brie.
PORM: Pasteurized and old raw milk cheese stored for 60 days or more.

Retailers value added share (ρ) and supply elasticity

To estimate this share a comparison is made between retail prices and producer prices. Such data are not available separately for camembert and brie, and an approximation is made using data on the overall cheese sector. The retail cheese price is provided by the Canadian Dairy Information Centre,[23] and equal to 12.45 CAD/kg.

The producer price is more complex to obtain. One solution consists in dividing the Canadian cheese production value by its volume. However, production value data are not available, and hence imports are used instead of domestic production to estimate the producer price. This approach assumes that the import price at the border does not include the retailers' margin but that this margin is included in the retail price. Cheese imports (in value and volume) are available on the Canadian Dairy Information Centre website. Using these data, the producer price equals to CAD 8.65/kg. Comparing consumer and producer prices, the retailers' share in the final consumer price is estimated at 0.31. The price elasticity of cheese supply is set at 0.2 for both foreign and domestic producers.

Willingness to pay for avoiding Listeria (wtp_r)

This draws on the value suggested by Hayes *et al.* (1995). Main microbiological hazards associated with raw milk cheeses consumption are *Listeria monocytogenes, salmonella* spp**,** *E. coli* O157H7 and staph aureus. In an experimental economics study, Hayes *et al*. (1995) found respondents willing to pay 15% to 30% more for food that is essentially completely safe from five pathogens found in the United States. This willingness to pay (WTP), which includes cost of illness plus averting behaviour, is often used as the social value of non contamination and is widely cited. This experiment did not focus on *Listeria* and participants were students, which is an obvious limitation since the student sample is an imperfect representative of the whole population. This study uses the

22. The individual elasticities are calculated as follows: $\varepsilon_{pr}^{d} = (\varepsilon - \gamma)/(1+v)$; $\varepsilon_{pp}^{d} = \varepsilon_{pr}^{d} * v + \gamma$; $\varepsilon_{rp}^{d} = \varepsilon_{pr}^{d} * v$; $\varepsilon_{rr}^{d} = \varepsilon_{pr}^{d} + \gamma$; where $v = (p_p q_p)/(p_r q_r)$

23. http://www.infolait.gc.ca/pdf/chretail_prices.pdf.

maximum value reported in Hayes *et al.* (1995) of 30% which corresponds to $wtp_r = 0.3$. However, this value is likely a lower bound in the context of health risks related to *Listeria*: students such as those surveyed by Hayes *et al.* (1995) have quite a different risk profile compared to, *e.g.* pregnant women, and can be expected to be less risk averse and hence to have a lower willingness to pay for hazard-free cheese than highly-vulnerable groups. The per-unit value of of the damage is determined with the wtp_r relative to the observed price p_r for the raw milk cheese. In other words, the WTP for avoiding *Listeria* is wtp_r, leading to a unit damage value of $wtp_r * p_r$. We will subject the level of the willingness to pay to sensitivity analyses presented below.

Mark-up for raw milk cheese reflecting taste preferences

As noted above, consumers value young raw milk cheese for its particular taste, and are willing to pay higher prices for these qualities compared to PORM qualities in spite of the potential health risks related to young raw milk cheese consumption. Unfortunately, empirical data on the consumers' willingness to pay for young raw milk cheese qualities are not available. We therefore assume the additional value to represent 10% of the price of raw milk camembert and brie, respectively, and subject this parameter to sensitivity analyses presented below.

Social damage from the consumption of young raw milk cheese

While consumers consider – to the degree they are informed – the risk of private consequences of sickness in their decision to consume young raw milk cheese, they generally do not consider related costs borne by the public health care system (*e.g.* in case of hospitalization) or by their employers (*e.g.* the loss of worktime). These additional costs can be significant and hence are important to be considered in this analysis. Unfortunately, data about these costs are unavailable. We assume a social willingness to pay for *Listeria*-free cheese wtp_s using the value for the private willingness to pay wtp_r discussed above. The social damage from young raw milk cheese consumption is estimated as $wtp_s * p_r * q_r$. It should be noted, however, that this value should be considered indicative only, as the real social willingness to pay is unknown, and the actual damage may be very different.

Share of population highly susceptible to Listeria (α)

Scientific investigations and experience have shown that some groups in the population face an above-average risk of diseases following young raw milk cheese consumption, due to the microbiological hazards that may be present in raw milk. These groups are pregnant women, young children, elderly and immune-compromised persons. Here the focus is on pregnant women (evaluated using number of births), the elderly (people aged 70 or over), and the immuno-compromised persons (evaluated using cancer prevalence data; in the middle of the 2000s, on average, 2.6% of the population in developed countries reported that they currently had a medically diagnosed cancer in the previous 15 years). We define α as the share of these groups combined in the total population. This share is calculated using demographic statistics provided on Statistics Canada website. For Canada, α equals 13.2%.

Share of informed and concerned population about the health risks associated with young raw milk cheese consumption (β)

Governments usually introduce education programmes to inform sensitive population groups on the risks associated with the consumption of raw milk products.[24] However, one can assume that part of the concerned population does not receive the information or does not fully understand it. Thus β measures the share of the concerned population that effectively knows about the risks. It is assumed that concerned and perfectly informed persons fully incorporate the (private) risk in their consumption decisions, which is equivalent to responding to a price equal to the actual market price augmented by the perceived damage related to the young raw milk cheese consumption.

On the other hand, the concerned but not informed population continues to consume young raw milk cheeses. Therefore, using the share (1-β), one can calculate the "cost of lack of information". Thus, this cost arises from uninformed consumption by a portion of the population that is potentially susceptible to the health risk. The parameter β is taken as exogenous and fixed at 0.6, which implies that only 60 per cent of the vulnerable population is effectively informed about the risk.

Calibration

With the data and estimates discussed above, the remaining constants of the supply and demand equations in the model can be calibrated, such that the model reproduces the baseline observations.

A5. Results

As mentioned above, we consider a counterfactual scenario in addition to the base situation to explore the welfare effects of authorizing young raw milk cheeses[25]:

- Baseline scenario: young raw milk cheese is authorized for imports from France, but not for domestic production. This scenario represents the actual situation in 2006.
- Counterfactual scenario: young raw milk cheese is not authorized for sale irrespective of its origin. We calculate welfare effects for consumer and producers (domestic, foreign and retailers), as well as the impact on the welfare costs of lack of information for concerned but uninformed consumers, and on the social damage (public health care, loss of worktime).

The welfare assessment is partial, in the sense that additional cost for assuring safety in the supply chain that may occur for industry as well as for the regulator are not taken into account.

Table A3 provides the estimated economic impact of raw milk cheese authorization on surpluses of agents for 2006. Results for the counterfactual scenario suggest that in the absence of young raw milk cheese all consumers face significant losses. Compared to the

24. For example, such programmes were enforced in New Zealand after the approval of Roquefort sales.

25. In this section, the term "young raw milk cheese" refers to qualities stored for less than 60 days only, whereas the term "pasteurized cheese" includes both pasteurized and raw milk cheese stored for 60 days or more.

base situation, the combined consumer surplus declines by almost CAD 7.9 million in the market for camembert and by some CAD 7.2 million in the market for brie. Given the large share of unconcerned consumers (*i.e.* those not belonging to the highly concerned groups defined earlier) in the population, the bulk of these losses would be borne by this group. The surplus change for concerned but uninformed consumers is the same as that for unconcerned consumers on a per capita (or per cent) base as the health risk related to young raw milk cheese does not alter their consumption decision, but this group faces an additional gain due to the reduction of the costs of lack of information, which partially compensates for the loss in consumer surplus. Concerned and informed consumers lose least on a per capita base, as their willingness to avoid the disease lets them consume less than average young raw milk cheese when it is available. Still, these 7.9% of the population bear some 6.5% of the total loss in consumer surplus in either of the two markets.

Table A3. Market and welfare impacts of a hypothetical removal of the authorization of raw milk cheese stored less than 60 days in Quebec (kg and CAD)

		Counter-factual scenario Ban of young raw milk cheese	
	Unit	**Camembert**	**Brie**
Supply PORM cheese[1]	kg	12 946	11 808
Supply young raw-milk cheese[2]	kg	-32 895	-21 064
Consumption PORM cheese[1]	kg	12 946	11 808
Consumption young raw milk cheese:[2] unconcerned	kg	-29 176	-18 682
Consumption young raw milk cheese:[2] concerned, uninformed	kg	-1 775	-1 136
Consumption young raw milk cheese:[2] concerned, informed	kg	-1 944	-1 244
Consumer welfare			
Unconcerned consumers	CAD	-6 980 652	-6 310 603
Concerned, uninformed	CAD	-424 630	-383 871
Subtract cost of lack of information	CAD	-21 084	-19 536
Concerned, informed	CAD	-512 698	-462 462
Producer welfare			
Domestic producers	CAD	1 440 229	1 282 429
Domestic retailers	CAD	344 577	296 974
Foreign producers	CAD	-673 268	-621 423
Societal costs[3]			
Public health spending, loss of work time, etc.	CAD	-44 181	-40 927
Aggregate partial welfare[4]			
Domestic welfare	CAD	-6 067 908	-5 517 070
Total welfare	CAD	-6 741 176	-6 138 493

1) Pasteurised and raw milk cheese stored for 60 days or more.

2) Raw-milk cheese stored for less than 60 days.

3) Indicative only as based on an arbitrarily assumed social willingness to pay.

4) Excludes additional costs for assuring safety in the supply chain possibly occurring for the industry as well as for the regulator, also excludes possible other risks linked to the consumption of raw milk cheese.

The impact on producers' profits is different between domestic and foreign producers due to the fact that the composition of cheese qualities varies: indeed, it is the (foreign) producers of young raw milk cheese who lose all the profits related to the markets in Quebec, whereas (domestic and foreign) producers of PORM cheese gain following the increase in demand and hence prices. Retailers benefit from the ban, too, as the losses on the young raw milk cheese market are outweighed by gains on the PORM cheese market.

Finally, the ban avoids additional costs for the society linked *e.g.* to public health care expenditures and losses of work time. Assuming the same willingness to pay on the side of the society as estimated for concerned consumers preferences, these saved costs amount to some CAD 44k and CAD 41k in the markets for camembert and brie, respectively, but the high level of uncertainty relative to these costs need to be reiterated here.

In total, and abstracting from the savings of additional costs for assuring safety in the supply chain, a ban of young raw milk camembert and brie – equivalent to the regulations before 2001 – would result in estimated costs at some CAD 6.1 million and CAD 5.5 million, respectively. Together with the profit losses of foreign producers, the estimated total loss would sum up to CAD 6.7 million and CAD 6.1 million, respectively.

It should be re-iterated that this welfare variation is partial since it abstracts from a number of cost items: additional costs of monitoring by national authorities; control and cleanliness costs faced by private cheese-makers and raw milk suppliers. The regulator will face costs for the development of a risk-based framework that facilitates local production and importation of such products. Once implemented, the regulator will also need to devote resources to monitoring of industry compliance with regulatory controls for young raw milk products. Industry operators may have to invest in new methods and facilities to assure a safe production of raw milk cheeses. They will also face ongoing costs associated with validating that their products comply with any relevant regulatory standards. In the event of an outbreak of illness related to raw milk cheeses the costs could be high for individual producers as well as the dairy industry as a whole. These costs are difficult to calculate, but they will nevertheless impact on the future perceived and the actual benefits. Such items would need to be included in Table A3 if they could be appropriately quantified, and could substantially alter the aggregate welfare estimates.

Another major problem relates to the measurement of consumer welfare changes in the case of the complete removal of an entire market, as simulated in the present scenario. Given that such a change no longer represents a "small" deviation from the base situation, the choice of the functional form used to represent market demand and hence consumers' preferences becomes crucial. The magnitude of the loss in consumer surplus strongly depends on the model deployed: taken the market for young raw milk cheese alone (*i.e.* ignoring for a moment the relationship to the market for PORM cheese), the total consumer surplus lost in the case of a ban would shrink significantly had we chosen a linear demand function instead of the isoelastic one used above, thus severely limiting the ability of the model in the present form to estimate net welfare changes of such policy changes. A richer data set would allow the data-based choice of the functional form, thus potentially avoiding this problem.

Sensitivity of results with respect to key assumptions

As noted above, a number of important parameters used to assess the change in the regulations relative to young raw milk cheese in Canada are uncertain or even unknown. To evaluate the results outlined above it is therefore important to know their sensitivity to changes in those parameters. Here, we focus on three particular parameters: the degree of substitutability between young raw milk and other cheese (*i.e.* the elasticity of substation), the willingness to pay for consumers as well as for the society, and the value added attributed to the perceived higher quality of young raw milk cheese. We discuss these parameters in this section.

Table A4 repeats the scenario results for camembert and sets them next to the corresponding results using alternative assumptions on the abovementioned parameters, while Table A5 does the same for the brie market. Both tables show that the results do depend on the value used for the elasticity of substitution between PORM and young raw milk cheese. Particularly, the estimated impact of a ban of young raw milk cheese on producers changes significantly: higher substitutability across cheese qualities means that consumers more easily switch to PORM cheese as young raw milk cheese becomes unavailable. In consequence, the increase in the PORM cheese price is more substantial, benefiting producers in Canada and abroad.

Table A4. Market and welfare impacts of a ban of young raw milk camembert with alternative assumptions on key parameters (kg and Canadian dollars)

	Base parameter assumptions	**Elasticity of substitution**	**Willingness to pay (private and social)**	**Quality mark-up**
		original: -1.2 **altered: -1.5**	original: 0.3 **altered: 1.0**	original: 0.1 **altered: 0.3**
Supply PORM cheese[1]	12 946	32 366	12 946	12 946
Supply young raw milk cheese[2]	-32 895	-32 895	-32 895	-32 895
Consumption PORM cheese[1]	12 946	32 366	12 946	12 946
Consumption young raw milk cheese[2]: unconcerned	-29 176	-29 306	-29 888	-29 176
Consumption young raw milk cheese[2]: concerned, uninformed	-1 775	-1 783	-1 818	-1 775
Consumption young raw milk cheese[2]: concerned, informed	-1 944	-1 807	-1 189	-1 944
Consumer welfare				
Unconcerned consumers	-6 980 652	-7 292 735	-7 103 844	-6 980 652
Concerned, uninformed	-424 630	-443 613	-432 123	-424 630
Subtract: cost of lack of information	-21 084	-21 178	-71 997	-21 084
Concerned, informed	-512 698	-597 073	-382 012	-512 698
Producer welfare				
Domestic producers	1 440 229	3 649 342	1 440 229	1 440 229
Domestic retailers	344 577	1 389 283	344 577	344 577
Foreign producers	-673 268	-557 068	-673 268	-673 268
Societal costs[3]				
Public health spending, loss of work time, etc.	-44 181	-42 640	-119 072	-44 181
Aggregate partial welfare[4]				
Domestic welfare	-6 067 908	-3 230 979	-5 942 105	-6 067 908
Total welfare	-6 741 176	-3 788 047	-6 615 373	-6 741 176

1) Pasteurised and raw milk cheese stored for 60 days or more.
2) Raw-milk cheese stored for less than 60 days.
3) Indicative only as based on an arbitrarily assumed social willingness to pay.
4) Excludes additional costs for assuring safety in the supply chain possibly occurring for the industry as well as for the regulator; also excludes possible other risks linked to the consumption of raw milk cheese.

The level of the willingness to pay for Listeria-free cheese has very little impact on the market equilibrium and hence consumer and producer surplus changes in the scenario. However, it directly changes the magnitude of both changes in costs of lack of information (borne by concerned but uninformed consumers) and in societal costs (public health care spending, loss of work time, etc.). In consequence, higher unit costs to both consumers and the society directly reduces the overall welfare loss of a young raw milk cheese ban, but also the total welfare gains of authorizing domestic production of young raw milk cheese.

Finally, the last columns of Tables A4 and A5 show that a different assumption on the quality mark-up for raw milk cheese has no effect on the welfare assessment, nor on the new market equilibrium. Given that the additional value is internalized in the decisions of all relevant agents (all consumer groups – no spill-over effects on the rest of the society) it only affects the calibration of the constants in the two demand functions, without implications for the behaviour in the model.

Table A5. Market and welfare impacts of a ban of young raw milk brie with alternative assumptions on key parameters (kg and Canadian dollars)

	Base parameter assumptions	Elasticity of substitution original: -1.2 **altered: -1.5**	Willingness to pay (private and social) original: 0.3 **altered: 1.0**	Quality mark-up original: 0.1 **altered: 0.3**
Supply PORM cheese[1]	11 808	29 521	11 808	11 808
Supply young raw milk cheese[2]	-21 064	-21 064	-21 064	-21 064
Consumption PORM cheese[1]	11 808	29 521	11 808	11 808
Consumption young raw-milk cheese[2]: unconcerned	-18 682	-18 766	-19 139	-18 682
Consumption young raw-milk cheese[2]: concerned, uninformed	-1 136	-1 142	-1 164	-1 136
Consumption young raw-milk cheese[2]: concerned, informed	-1 244	-1 156	-760	-1 244
Consumer welfare				
Unconcerned consumers	-6 310 603	-6 441 584	-6 422 958	-6 310 603
Concerned, uninformed	-383 871	-391 838	-390 705	-383 871
Subtract: cost of lack of information	-19 536	-19 623	-66 709	-19 536
Concerned, informed	-462 462	-524 419	-343 272	-462 462
Producer welfare				
Domestic producers	1 282 429	3 216 209	1 282 429	1 282 429
Domestic retailers	296 974	1 214 935	296 974	296 974
Foreign producers	-621 423	-512 000	-621 423	-621 423
Societal costs[3]				
Public health spending, loss of work time, etc.	-40 927	-39 488	-110 279	-40 927
Aggregate partial welfare[4]				
Domestic welfare	-5 517 070	-2 867 586	-5 400 545	-5 517 070
Total welfare	-6 138 493	-3 379 586	-6 021 968	-6 138 493

1) Pasteurised and raw milk cheese stored for 60 days or more.

2) Raw-milk cheese stored for less than 60 days.

3) Indicative only as based on an arbitrarily assumed social willingness to pay.

4) Excludes additional costs for assuring safety in the supply chain possibly occurring for the industry as well as for the regulator, also excludes possible other risks linked to the consumption of raw milk cheese.

Path dependency of changes in the consumer surplus

As noted above, the use of the consumer surplus as a welfare measure results in a path dependency problem: While in the analysis above the change in consumer surplus is calculated by first looking at the young raw milk cheese market and second at the PORM cheese markets, this order is arbitrary despite the fact that causality in the scenarios chosen works in this order. In addition to the sensitivity analyses above it is therefore important to verify that results do not significantly alter with the order of market consideration. Indeed, none of the changes in consumer surplus discussed above is affected by the choice of the calculation order by more than 0.25%.

Limitations to the analysis

As mentioned, the analysis shown here is subject to a number of limitations which reduce the precision of the results shown above. In particular, these limitations include:

- Most importantly, analysing the ban of an entire market such as of the one for young raw milk camembert and brie by estimating its welfare effects requires the calculation of the total consumer surplus extracted from the consumption of that particular product, rather than calculating only a relatively small change in the consumer surplus due to changes in market prices. In consequence, the functional form used becomes crucial as it determines the shape, and hence the size, of the "triangle" left of the demand function. As discussed above, the calculated consumer surplus can change by an order of magnitude using different functional forms. Net welfare effects of such a policy change can therefore vary significantly and might even change signs, comprising its usefulness for policy recommendations.

- The analysis does not consider costs of listeriosis due to the consumption of young raw milk cheese by non-vulnerable consumers. As noted, on average across the general population the health risk associated with consuming raw milk products is typically assessed as small. However, every person consuming young raw milk cheese faces a certain risk of sickness, even though consequences for most people are not severe. As the study only considers highly vulnerable parts of the population, the risk of other groups – which may or may not be informed – is neglected, thus underestimating the total costs related to young raw milk cheese consumption.

- Similarly, in focusing only on *Listeria*, the cost of food borne diseases associated with other pathogens such as *Esherichia coli* and *Staphylococcus aureus* are not taken into account. Again this represents a bias to underestimate total costs related to young raw milk cheese consumption.

- Additional enforcement costs to government and additional costs to government in the event of a listeriosis outbreak are not accounted for.

A6. Refinements

The analytical framework used in this report is admittedly simple, but it allows many extensions and refinements. In order to improve the accuracy of the estimations or to address different regulatory problems, some extensions could be integrated into the model presented here. In all cases, the accuracy of data is of paramount importance. The robustness of results has been tested using different parameter values and assumptions. Its dependency on the functional form for the representation of demand, however, poses a serious problem requiring further thinking.

As the new Quebec regulation for allowing domestic raw milk cheese stored less than 60 days is fairly recent (August 2008) and likely to be outweighed by the disruptions following the listeriosis outbreak in that same year, data on the response of domestic producers to supply this particular quality is not available. Even for 2006, information on actual consumption and imports of raw milk cheese stored for less than 60 days is missing. This lack is obviously an important limitation. One solution would be to renew the analysis at a later date if better data about the consumption of young raw milk and PORM cheeses becomes observable. This also would allow more accurate estimations of direct- and cross-price elasticities.

Another improvement could consist of eliciting people's values for young raw milk cheese and avoidance of *Listeria* for Canada, rather than relying on an estimate obtained from the literature. Several methods to arrive at such estimates are discussed in OECD (2008), and include contingent valuation methods, choice experiments and experimental economics (including lab, field or natural experiments).

An alternative approach to valuation of health risk is based on the cost of illness. The cost of mortality and morbidity and evaluating in money terms the benefits of government action resulting in a reduction of sanitary risk. Statistical methods are used to estimate the risk through dose-effect relationships. With the *illness cost* method, a value is placed on the reduced morbidity resulting from a regulation, based on an estimate of medical costs and productivity losses due to illness (Buzby *et al.*, 1996). In the context of young raw milk cheese one could take into account the probability of cases of listeriosis linked to the entry of young raw milk cheese. These methodologies may be incorporated into the cost-benefit framework proposed here, in particular for evaluating the damage for which consumers are not aware.

The model also abstracted from any regulatory cost linked to the entry of young raw milk cheese. For instance, Quebec reinforced safety measures after the authorization of young raw milk cheese: "Under the new rules, Quebec will require each cheese maker to know his or her milk supplier personally and to be knowledgeable about the dairy operation in question. As well, milk suppliers for this specialty segment of the market will be subjected to much higher standards of cleanliness than those imposed even on France's raw milk cheese producers."[26] These safety measures increase the costs for firms and the regulator, but were not quantified in this study. They could be compared to the partial welfare estimates presented here in order to assess whether the net social benefit of authorizing young raw milk cheese is positive or negative.

26. http://www.canada.com/montrealgazette/news/editorial/story.html?id=0ae042c0-306f-4f20-bc18-c0fbf32b409c

A7. Conclusions

This study empirically applies a cost-benefit framework to regulations related to raw milk camembert and brie in the Canadian province of Quebec. The results suggest that the Quebec authorization of raw milk camembert and brie stored for less than 60 days may have positive implications for national welfare as well as for exporters of camembert and brie. Gains to domestic consumers from larger choice and higher supplies might outweigh greater health risk which is evaluated with existing willingness to pay information. However, the estimates are partial as they exclude additional regulatory and monitoring cost, and additional cost for the cheese supply chain that may arise in relation to compliance with stricter production standards. They also do not consider costs related to other food borne diseases and those related to less vulnerable parts of the population. Furthermore, the results are conditional on the model and, to a lesser extent, parameter values used. Most importantly, the magnitude of the effects on consumer welfare strongly depends on the functional form deployed in the model. If the sum of the above-mentioned additional costs exceeds the benefits calculated in this study and/or if the actual consumer surplus from the consumption of young raw milk camembert and brie cheeses is significantly smaller than estimated here, the net welfare effect becomes negative.

This report has taken a particular approach to valuing potential health damage. The willingness to pay method allows the estimation of consumer reactions and cross-market effects, which is a clear advantage of this approach. A limitation of the approach is the difficulty obtaining good estimates of relevant parameters. Alternative ways to value potential damage are QALYs and cost of illness methods, which could perhaps be employed to complement the broader economic assessment pursued in this report. However, the reliability of those methods also depends on the quality of data, and they cannot incorporate market effects of changes in regulations. Some of the risk assessment methods used in administrations can help to avoid the difficult trade-offs between additional incidences of food borne disease and economic benefits and costs.

Data availability is critical, whatever method is chosen. This study has found that trade and production data are not readily available at such a detailed product level, and prices could only be approximated using some observations on transactions in Canada. Herein lays a major challenge for assessment of non-tariff measures: these measures are relevant at a very detailed product level, and the regulations are often very specific. This level of detail is typically not matched by the way in which production and trade statistics are collected.

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Appendix A1.

The Model

The PORM and young raw milk cheeses[27] are assumed to be homogenous (*i.e.* same quality attributes) except for two specific characteristics, namely (1) the specific taste for young raw milk cheeses, (2) the risk aversion for microbiological hazards. In our model, we focus more specifically on *Listeria*. Except for the two special characteristics, all consumers have the same preferences regarding the direct utility linked to the product, which is a necessary simplification coming from the lack of data linked to the young raw milk cheese.

Demand for PORM and young raw milk cheese

Assuming isoelastic demand, demand for PORM and young raw milk cheese can be described by the following general equation:

$$q_i = a_i * \prod_j p_j^{\varepsilon_{ij}^d} \qquad (1)$$

where q_i represents the quantity of cheese quality i consumed ($i \in \{p, r\}$, with the indices p and r representing PORM and young raw milk cheese, respectively), *a* a constant and p_j the retail price of the different cheeses ($j \in \{p, r\}$). ε_{ij}^d represents the price elasticity of demand for quality i relative to the price of quality j. The price elasticities at this level of detail are not observed and are therefore calculated from the own-price elasticity of cheese (any quality) and an assumed elasticity of substitution γ across the two qualities.

We assume that, compared to PORM cheese, two additional attributes are attached to young raw milk cheese: first, consumers perceive an additional quality of young raw milk cheese s_r. Secondly, consumers have an aversion linked to *Listeria* which is captured by the term Ir_r. The parameter *I* represents the knowledge regarding the *Listeria* aversion brought by young raw milk products. If consumers are not aware of the specific characteristic then *I*=0.Conversely, *I*=1 means that consumers are aware of the *Listeria* aversion characteristic and can unambiguously identify the characteristic and adjust their consumption. The perceived damage associated with the consumption of the good with the *Listeria* is denoted $r_{r,i}$.

Aggregate demands over different types of consumers allow us to take into account different reactions. For simplicity, we assume that the perceived additional quality linked

27. For easier reading in what follows we group all cheese other than raw milk cheese stored for less than 60 days under the term "PORM cheese" (pasteurized cheese and older raw milk cheese, *i.e.* cheese authorized before 2001), while the term "young raw milk cheese" refers to raw milk cheese stored for less than 60 days only (*i.e.* cheese that became authorized in Quebec with the legislative changes from 2001 and 2008).

to young raw milk cheese is the same across consumers. Let α be the proportion of consumers highly concerned by *Listeria* (elderly people and pregnant women). The remaining proportion ($1-\alpha$) of consumers is not concerned by the *Listeria*. This assumption abstracts from any *Listeria* aversion by consumers outside this group of highly-concerned consumers.[28]

Let β be the proportion of highly-concerned consumers who are perfectly informed about the risk and completely avoid the young raw milk products (as advised by medical doctors). The remaining proportion ($1-\beta$) of highly-concerned consumers is not informed and they consume those products. In this case, and furthermore assuming that the per-unit damage $r_{r,i}$ is the same across all concerned consumers (irrespective of their level of information) and reflected by the willingness to pay for uncontaminated food obtained from experimental economics (see section 4) relatively to the observed price p_r of young raw milk cheese, it is possible to compute the demand of three subgroups g.

$$Q_{p,g}^{d} = \omega_g * \left[a_p * p_p^{\varepsilon_{pp}^{d}} * \left(\frac{p_r * (1 + Ir_r)}{(1 + s_r)} \right)^{\varepsilon_{pr}^{d}} \right] \quad \text{PORM cheese} \qquad (2a)$$

$$Q_{r,g}^{d} = \omega_g * \left[a_r * p_p^{\varepsilon_{rp}^{d}} * \left(\frac{p_r * (1 + Ir_r)}{(1 + s_r)} \right)^{\varepsilon_{rr}^{d}} \right] \quad \text{young raw milk cheese} \qquad (2b)$$

For the non-concerned consumers, with a share in the population $\omega_A = (1-\alpha)$, the per-unit damage of consuming young raw milk cheese is assumed to be zero ($r_{r,A}=0$), resulting in aggregated demand for this group to be

$$Q_{p,A}^{d} = (1-\alpha) * \left[a_p * p_p^{\varepsilon_{pp}^{d}} * \left(\frac{p_r}{(1 + s_r)} \right)^{\varepsilon_{pr}^{d}} \right] \quad \text{PORM cheese} \qquad (3a)$$

$$Q_{r,A}^{d} = (1-\alpha) * \left[a_r * p_p^{\varepsilon_{rp}^{d}} * \left(\frac{p_r}{(1 + s_r)} \right)^{\varepsilon_{rr}^{d}} \right] \quad \text{young raw milk cheese} \qquad (3b)$$

For the highly-concerned but non-informed consumers with a population share of α ($1-\beta$), the unit damage r_r is positive, but as I (the level of knowledge or awareness) is zero, aggregated demand for this group is

$$Q_{p,B}^{d} = \alpha(1-\beta) * \left[a_p * p_p^{\varepsilon_{pp}^{d}} * \left(\frac{p_r}{(1 + s_r)} \right)^{\varepsilon_{pr}^{d}} \right] \quad \text{PORM cheese} \qquad (3c)$$

28. In reality, most consumers are likely to be concerned by listeria-contaminated food to some degree, the level of which represents a continuum within the population. Here we simplify by focusing on the additional risk linked to the authorization of raw milk cheese on elderly people and pregnant women only who are considered the particularly highly-concerned share of the population.

$$Q^d_{r,B} = \alpha(1-\beta) * \left[a_r * p_p{}^{\varepsilon^d_{rp}} * \left(\frac{p_r}{(1+s_r)} \right)^{\varepsilon^d_{rr}} \right] \quad \text{young raw milk cheese} \qquad (3d)$$

For this group, the damage of *Listeria*-contamination is not internalized and hence does not impact demand decisions. It is, however, taken into account in the partial welfare calculation. Here, the overall damage or welfare loss for lack of information taken into account in the welfare is $r_r p_r Q^d_{r,B}$. As mentioned above, the value of r_r is determined with the willingness to pay (WTP) given by the experimental economics (see in section 4) relatively to the observed price p_r for the raw milk cheese. In other words, the willingness to pay (WTP) for avoiding the *Listeria* is $wtp_r = r_r$.

The highly-concerned and informed consumers (with a population share of $\alpha * \beta$), fully internalize the damage into their demand decisions and reduce the consumption of raw milk cheese (as advised by medical doctors). For the highly-concerned and informed consumers (with *I=1*), the aggregated demand is

$$Q^d_{p,C} = \alpha * \beta * \left[a_p * p_p{}^{\varepsilon^d_{pp}} * \left(\frac{p_r * (1+r_r)}{(1+s_r)} \right)^{\varepsilon^d_{pr}} \right] \quad \text{PORM cheese} \qquad (3e)$$

$$Q^d_{r,C} = \alpha * \beta * \left[a_r * p_p{}^{\varepsilon^d_{rp}} * \left(\frac{p_r * (1+r_r)}{(1+s_r)} \right)^{\varepsilon^d_{rr}} \right] \quad \text{young raw milk cheese} \qquad (3f)$$

Total demand for PORM and young raw milk cheese can be obtained by summing up the corresponding equations (3a), (3c) and (3e), and (3b), (3d) and (3f), respectively:

$$Q^d_p = \hat{Q}^d_p * \left(\alpha * \beta * (1+r_r)^{\varepsilon^d_{pr}} + 1 - \alpha * \beta \right)$$

$$\text{with} \quad \hat{Q}^d_p = a_p * p_p{}^{\varepsilon^d_{pp}} * \left(\frac{p_r}{(1+s_r)} \right)^{\varepsilon^d_{pr}} \quad \text{PORM cheese} \qquad (4a)$$

$$Q^d_r = \hat{Q}^d_r * \left(\alpha * \beta * (1+r_r)^{\varepsilon^d_{rr}} + 1 - \alpha * \beta \right)$$

$$\text{with} \quad \hat{Q}^d_r = a_r * p_p{}^{\varepsilon^d_{rp}} * \left(\frac{p_r}{(1+s_r)} \right)^{\varepsilon^d_{rr}} \quad \text{young raw milk cheese} \qquad (4b)$$

It should be noted that in the case of an import ban for young raw milk cheese stored for less than 60 days, Q_r^d becomes zero, equivalent to a price for that cheese becoming (infinitely) large.

Supply of pasteurized and raw milk cheese

On the supply side, we assume isoelastic supply functions, defined as $Q_p^s = c_p{}^{-\varepsilon_p} * p_p{}^{\varepsilon_p}$ for the PORM cheese and $Q_r^s = c_r{}^{-\varepsilon_r} * p_r{}^{\varepsilon_r}$ for the young raw milk cheese.

Welfare calculations

Let σ be the import shares in the domestic consumption of either cheese type, and ρ be retailers' value added share in the final product price (which we assume to be the same for both PORM and young raw milk cheese, then profits for domestic producers (Π_D), foreign producers (Π_F) and retailers (Π_R) can be calculated as

$$\Pi_D = (1-\rho)\left[(1-\sigma_p)\Pi_p + (1-\sigma_r)\Pi_r\right]$$

$$= (1-\rho)\left[(1-\sigma_p) * c_p{}^{-\varepsilon_p} * \frac{1}{1+\varepsilon_p} * p_p{}^{1+\varepsilon_p} + (1-\sigma_r) * c_r{}^{-\varepsilon_r} * \frac{1}{1+\varepsilon_r} * p_r{}^{1+\varepsilon_r}\right]$$

$$\Pi_F = (1-\rho)\left[\sigma_p \Pi_p + \sigma_r \Pi_r\right]$$

$$= (1-\rho)\left[\sigma_p * c_p{}^{-\varepsilon_p} * \frac{1}{1+\varepsilon_p} * p_p{}^{1+\varepsilon_p} + \sigma_r * c_r{}^{-\varepsilon_r} * \frac{1}{1+\varepsilon_r} * p_r{}^{1+\varepsilon_r}\right]$$

$$\Pi_R = \rho\left[\Pi_p + \Pi_r\right] = \rho\left[c_p{}^{-\varepsilon_p} * \frac{1}{1+\varepsilon_p} * p_p{}^{1+\varepsilon_p} + c_r{}^{-\varepsilon_r} * \frac{1}{1+\varepsilon_r} * p_r{}^{1+\varepsilon_r}\right]$$

Profit changes for these agents are calculated as the differences between profits in the different scenarios and those in the base situation.

Regarding the consumers, their surplus changes are determined by integrating demand over the subgroup of consumers, bearing in mind the health risk for concerned but uninformed consumers as noted above. Surpluses for the groups of unconcerned (A), concerned but uninformed (B) and concerned and informed consumers (C) are hence given by

$$\Delta CS_A = (1-\alpha) * \left(\frac{\widehat{Q}_r^{d,0}}{\left(p_r^0\right)^{\varepsilon_{rr}^d}} * \frac{\left(p_r^0\right)^{\varepsilon_{rr}^d+1} - \left(p_r^1\right)^{\varepsilon_{rr}^d+1}}{\varepsilon_{rr}^d+1} + \frac{\widehat{Q}_r^{d,1}}{\left(p_p^1\right)^{\varepsilon_{pp}^d}} * \frac{\left(p_p^0\right)^{\varepsilon_{pp}^d+1} - \left(p_p^1\right)^{\varepsilon_{pp}^d+1}}{\varepsilon_{pp}^d+1} \right)$$

$$\Delta CS_B = \alpha(1-\beta) * \left(\frac{\widehat{Q}_r^{d,0}}{\left(p_r^0\right)^{\varepsilon_{rr}^d}} * \frac{\left(p_r^0\right)^{\varepsilon_{rr}^d+1} - \left(p_r^1\right)^{\varepsilon_{rr}^d+1}}{\varepsilon_{rr}^d+1} + \frac{\widehat{Q}_r^{d,1}}{\left(p_p^1\right)^{\varepsilon_{pp}^d}} * \frac{\left(p_p^0\right)^{\varepsilon_{pp}^d+1} - \left(p_p^1\right)^{\varepsilon_{pp}^d+1}}{\varepsilon_{pp}^d+1} \right)$$

$$\Delta CS_C = \alpha\beta * \left(\frac{\widehat{Q}_r^{d,0}(1+r_r)^{\varepsilon_{rr}^d}}{\left(p_r^0\right)^{\varepsilon_{rr}^d}} * \frac{\left(p_r^0\right)^{\varepsilon_{rr}^d+1} - \left(p_r^1\right)^{\varepsilon_{rr}^d+1}}{\varepsilon_{rr}^d+1} + \frac{\widehat{Q}_r^{d,1}(1+r_r)^{\varepsilon_{pr}^d}}{\left(p_p^1\right)^{\varepsilon_{pp}^d}} * \frac{\left(p_p^0\right)^{\varepsilon_{pp}^d+1} - \left(p_p^1\right)^{\varepsilon_{pp}^d+1}}{\varepsilon_{pp}^d+1} \right)$$

Note the fact that the calculation of consumer surplus changes in principle is path-dependant: the equations above assume that first the young raw milk cheese market is changed (as in fact it is the raw milk cheese market seeing the direct impact of the policy differences across scenarios) with the market for PORM cheese following (as the impact on PORM cheese prices is an indirect one spilling over from the young raw milk cheese market). In reality, these changes are, notwithstanding the logic of causality, happening simultaneously, so the calculation could as well turn the order around in which the two markets are altered. The results section discusses the implications of this potential problem.

In addition to the change in consumer surplus, the group of concerned but uninformed consumers also faces changes to the cost of lack of information (CLL_B) as follows:

$$CLI_B = wtp_r * p_r * Q^d_{r,B}$$

Finally, the society as a whole bears additional costs related to the consumption of potentially *Listeria*-contaminated cheese beyond those born by the consumers and taken into account in the calculation of the consumer surplusses. These societal costs include issues such as additional public medical care spending and loss of work hours. While data on such costs are unavailable, we consider these costs by adding a societal welfare element similar to the additional losses for concerned but uninformed consumers. If wtp_s represents the society's willingness to pay for the avoidance of such societal costs relative to the price of raw milk cheese, these costs can be estimated by

$$SC = wtp_s * p_r * \left(Q^d_{r,B} + Q^d_{r,C}\right)$$

The impact of policy changes on the partial domestic welfare (without safety and regulatory costs for the industry and the regulator) is

$$\Delta W_D = \Delta\Pi_D + \Delta\Pi_R + \Delta CS_A + \Delta CS_B + \Delta CS_C - \Delta CLI_B - \Delta SC$$

whereas the change in the partial global welfare is given as

$$\Delta W_D = \Delta\Pi_D + \Delta\Pi_F + \Delta\Pi_R + \Delta CS_A + \Delta CS_B + \Delta CS_C - \Delta CLI_B - \Delta SC\ .$$

Part B.

Economic impact of selected OECD countries standards on Asian shrimp production: evidence from a cost-benefit analysis

World shrimp production grew rapidly during the last two decades. In 1990, 2 637 thousand tonnes of shrimps were produced in the world. In 1995 production reached 3 372 tonnes and between 1995 and 2006, it almost doubled with 6 624 tonnes of shrimps produced worldwide in 2006. 80 % of the world production in 2006 came from Asia, with China, Thailand, Indonesia, India and Viet Nam being the top five world producers of shrimps (Appendix Figures B1 and B2). The growth occurred mostly due to expansion of shrimp farming and consequently farmed shrimps are at the centre of the analysis.

The growth in shrimp production was followed by a significant rise in trade. Between 1996 and 2006, world imports of shrimps in terms of quantity increased by 69%, from 1 037 to 1 752 thousand tonnes.[29] OECD countries[30], in particular EU[31], the United States and Japan, are the main importing countries. In 2006, OECD imports represent 84.7% of world shrimp imports in quantity terms and 91.5% in value terms (Appendix Table B1).

About half (46.4%) of OECD value-based imports of shrimps come from the top five world producers: China, Thailand, Indonesia, India and Viet Nam. Thailand is the main exporter to the OECD countries (11.7%), followed by Viet Nam (10.8%), Indonesia (9.4%), and India (8.5%). China, despite being the main world shrimp producer, appears only in sixth position as a large part of Chinese production is consumed domestically (Tables B2 and B3 in the Appendix).

The shrimp boom has brought up some important issues. Among the most important are health costs as shrimps often contain diseases (*e.g.* salmonella), pesticides and/or harmful drug and antibiotic residues (such as chloramphenicol). Concerns are also related to the environment (*e.g.* destruction of mangroves). Other issues are related to the illegal use of areas for shrimp aquaculture and corruption of local authorities, as well as bad working conditions (employment of children and of illegal immigrants).

29. Increase in value-based imports is smaller. Between 1996 and 2006, value imports only increase by 28%, which suggests a decrease in the world price of shrimps.

30 . No OECD data used and shown in Part B includes data related to non-OECD EU member countries.

31. In 2006, more than 99% of EU imports went to EU countries that are members of the OECD.

Part B focuses on health concerns. Over the last decade, some OECD countries rejected several import shipment of shrimps on health and safety grounds, imposed temporary import bans, and asked for stronger health and safety controls. OECD countries' standards and requirements[32], that these countries have imposed motivated by consumer protection, obviously affect production and exports of shrimps by DCs and LDCs.

In Part B, we investigate the economic impacts of such standards on farmed shrimp production. In particular, we study if these standards, given the size of demand by OECD countries, could be an incentive for exporting countries to adapt and improve their production methods. In the past, some countries, *e.g.* Thailand, improved their production scheme by implementing Better Management Practices (BMP) programmes and/or switching production from traditional shrimp species to more disease-resistant species. We examine whether their approach extended to other exporting countries, namely India, Indonesia and Viet Nam, would bring positive welfare effects.

Four scenarios are considered for each of the three countries in question. In the first two scenarios, we assume no changes in the current production scheme. In the baseline scenario, which replicates the current situation, OECD shrimp-importing countries inspect some shrimp consignments. These controls are not systematic and Asian producers can export a certain share of contaminated shrimps to OECD markets. In the second scenario, OECD countries ban shrimp imports from Asian countries due to health and safety risks. In the third scenario, we estimate the welfare effect of implementing BMP measures. Here Asian countries can export their shrimps to OECD countries, but BMP measures result in higher production costs. In the last scenario, we assume, in addition to BMP measures, a switch in production towards more disease-resistant shrimp variety. We assume that this new shrimp specie accounts for 80% of the production. Imports are allowed again in OECD countries. However, production costs and export revenues differ from previous scenarios (production costs and prices are different for each shrimp species).

We apply the cost-benefit analysis (CBA) framework. Given the focus of Part B, we analyse exclusively the supply side, *i.e.* we do not consider consumer welfare effects induced by a change in production. The basic CBA framework developed in OECD (2008) is extended to account fully for foreign producer side. In particular, foreign supply is augmented to include variable costs related to the adoption of improved production methods following health and safety standards imposed in importing countries.

A previous study conducted by the World Bank analysed the strategies and compliance costs of the various stakeholders in the Thai shrimp sector with international agro-food standards (World Bank, 2005). We use some of the compliance costs estimated by the World Bank in our cost-benefit analysis.

We conclude that health and safety standards imposed by importing countries lead to improvements of production methods in the exporting countries that increase foreign producers' welfare. In particular, if OECD countries were to ban

32. Individual OECD countries have their own standards and requirements regarding shrimps imports.

shrimp imports for health reasons, substantial profit incentives exist in exporting countries to adopt improved production methods in order to regain access to OECD countries' markets. However, even if trade was allowed again, improved production methods accompanied by implementation of more disease resistant shrimp varieties could decrease producer profits of exporting countries relative to the base situation with limited market access if the price discount for the smaller shrimp variety is too large.

The rest of Part B is organised as follows. The next section describes standards and requirements applied by several OECD countries on shrimp imports. Past import rejections are mentioned as well as improvements made by some Asian countries in their production scheme. Section B2 presents the cost-benefit framework for the assessment of the economic impacts of OECD standards on Asian shrimp production. Data and calibration are exposed in Section B3. Section B4 reports our results and considers their implications for the merits of OECD standards on shrimp imports. Section B5 briefly discusses possible extensions to this analysis. Section B6 concludes.

B1. OECD countries import requirements

Several OECD countries started to express strong health concerns about antibiotic and drug residues in shrimp imports at the beginning of the 2000s. In 2001, after detection of high levels of antibiotic and drug residues, the EU required bacteria-free and antibiotic-free shrimp imports. Canada, Japan and the United States shortly moved to similar requirements.

Antibiotics, such as chloramphenicol, are commonly used by shrimp producers to fight bacteria (*e.g.* salmonella) and to increase shrimp productivity, however, they are highly toxic to humans. The Joint FAO/World Health Organization Expert Committee on Food Additives concluded that the chloramphenicol can cause genetic damage, cancer and an aplastic anemia, a fatal disease in which bone marrow stops producing red and white blood cells. A very low concentration of chloramphenicol can be enough to trigger this fatal illness. Moreover, research shows that any concentration of chloramphenicol is potentially lethal for humans and it has not been possible to establish a safe level of human exposure to it.

The Sanitary and Phytosanitary[33] (SPS) Agreement allows countries to impose trade restrictions for health and safety reasons based on scientific risk assessments. To deal with the antibiotic and drug residue issue, some OECD countries impose strong controls on shrimp imports. To that end, two main approaches are applied. Some countries, such as EU countries, impose strict equivalence-based import regime. Only countries that have established the equivalence of their food safety procedures with the European ones can export to the EU. Furthermore, within an approved country, only certified producers,

33. As shown by Buzby *et al.* (2008), fishery and seafood products are the second top imported food category refused due to food safety and other violations under FDA law between 1998 and 2004 (20.6% of total violations). The authors also highlight that salmonella is the most common violation for a pathogen adulterant, accounting for 63% of pathogen violations.

i.e. producers that have demonstrated the equivalence of their safety standards and controls with the European ones, are allowed to export to the EU market. Other countries, such as Japan or Canada, apply a risk analysis approach to ensure the food safety of their seafood imports. In addtion, both approaches require border-controls and on-site inspections of aquaculture production, processing and distribution facilities to be performed. According to the Southern Shrimp Alliance (2007), the United States import regime seems to be less strict compared to regimes applied by the two other main OECD shrimp importers (EU and Japan). The US Food and Drug Administration (FDA) relies only on point-of-entry inspections and does not impose standards equivalence or certification as a prerequisite for entry into the US market.

When prohibited antibiotic and drug residues are found, shrimp consignments are rejected by OECD shrimp-importing countries. Furthermore, after repeated positive tests for chloramphenicol and other residues, importing countries impose 100% testing or temporary bans on imports. Being main world producers and exporters, Asian countries are particularly affected by these policies. For example, the EU ban on Thai shrimp imports between August and December 1997 was estimated to have cost the Thai industry about USD 15 million (FIAS, 2006).

The following list provides some examples of 100% testing requirements and bans imposed by main OECD importers of shrimps (EU, United States, Japan and Canada) on Asian products contaminated with antibiotics residues:[34]

- In 2001, after detection of high levels of chloramphenicol residues, the EU banned any consignment of shrimp from China, India, Pakistan and Southeast Asian countries which tested positive. Canada, Japan and the United States moved to similar bans.
- In January 2002, the EU imposed a 30-month ban of shrimp imports from China because of illegal antibiotic use. In July 2004, the EU started to import Chinese shrimp again only after the Chinese government guaranteed it would test 100% of shrimp exports.
- In 2002, the EU destroyed three large Indian consignments of shrimp after detection of chloramphenicol.
- In May 2002, the United States detected chloramphenicol in imported Chinese shrimp.
- In 2004, Japanese authorities rejected Indonesian shrimps contaminated by chloramphenicol.
- Between 2003 and 2005, Canada imposed 100% testing of seafood imports from Viet Nam after repeated detection of chloramphenicol.

34. This list is non-exhaustive. We restrict our focus to Asian shrimps. However, OECD countries also rejected shrimps produced in other countries and contaminated with antibiotics residues. For example, in February 2007, the EU banned shrimp imports from Suriname after a September 2006 on-site inspection showed very high levels of antibiotic residues and other contaminants. The US also found chloramphenicol in Mexican shrimps.

- In 2005, after an on-site inspection, the EU maintained its import ban on Cambodian seafood products.
- In 2006, the United States rejected shrimp imports from China because of repeated antibiotics contamination (on-site inspection revealed that 15% of the samples were contaminated with drug residues)
- In December 2006, Japan imposed 100% testing for Vietnamese shrimps after repeated chloramphenicol findings (6.7% of shrimp imports from Viet Nam were tested positive).
- In 2007, EU imposed a ban on Thai shrimp contaminated with chloramphenicol.
- In April 2007, the EU decertified all seafood producers from Pakistan after on-site review of seafood system in Pakistan revealed significant deficiencies in inspections, traceability and information regarding HACCP.

In response to standards and bans imposed by many OECD countries, and given the importance of OECD markets for shrimp exports, Asian countries have tried to improve their production methods in several ways.

Some Asian countries have banned the use of antibiotics (especially of chloramphenicol). In 2001, the Indonesian authorities reiterated chloramphenicol-banning regulation that had been enacted in 1982 and established a special task force, at both the regional and national levels, to enforce the law. In 1999, the Thai gouvernment banned the import and use of chloramphenicol and nitrofuran.[35] Nevertheless, such bans pose a great dilemma for shrimp producers using chloramphenicol to fight diseases, such as salmonella. For them, it is nearly impossible to produce shrimps free from both chloramphenicol and the disease.

Another way in which shrimp production has been improved is the implementation of Better Management Practices programmes. Such programmes target environment protection, improve shrimp health/production, and improve food safety and socio-economic sustainability. They help to reduce the risk of diseases, use more efficiently the inputs and reduce the use of chemicals. They also allow an easier access to loans and to markets. Programmes are often defined and realized with the collaboration of intergovernmental organizations (*e.g.* the FAO or the NACA[36]), non-governmental organizations (such as the WWF) or governments from developed countries (*e.g.* the Australian government). Although the implementation of BMP does not solve all shrimp disease problems, the outcomes are usually positive. Productivity and profitability of shrimp farms are improved. Estimation suggests that implementation of BMPs in India induced a reduction in disease risks by 7% in 2003, 20% in 2004 and 27% in 2005 and 2006. Profitability in farms applying BMPs was more than twice higher than in farms which did not apply BMP (Corsin, 2008). Among some of the examples of such programmes are:[37]

35. Chloramphenicol was nonetheless discovered by European customs in Thai shrimps in 2007. This raises the problem of the adoption *vs*. the enforcement of regulations.

36. Network of Aquaculture Centres in Asia-Pacific

37. For a detailed description of some of these programmes, see Corsin (2008).

- NACA/Marine Products Export Development Authority (MPEDA) Farm demonstration in India (2002)
- 2004-2005 NACA BMP projects in Viet Nam
- Australian Centre for International Agricultural Research (ACIAR) in Indonesia and Thailand
- NACA, FAO, WWF in Indonesia (post-tsunami)
- NACA in Iran
- WWF in Viet Nam
- Government of Viet Nam
- ACIAR BMP network

Finally, in order to minimize the use of chemicals and reduce the risks of importers' restrictive trade policies, producers may switch to a more disease-resistant shrimp variety. Penaeus Vannamei is an example of a species that does not require as much chemical treatment as the traditional Black Tiger variety[38] and is more disease-resistant. This species has been successfully introduced in Asia in 2000 (Figure B4 in the Appendix). Among other advantages of this species are: the easiness of cultivation, shorter production time, and lower feed costs. However, Vannamei shrimps are smaller than Black Tigers, and therefore their price is cheaper. Our last scenario focuses on welfare effects of implementing the new type of shrimp to the extent that it would account for 80% of the shrimp production.

B2. A simple model

We assume that the aquaculture production is composed of two shrimp species: the traditional Black Tigers and a more disease-resistant variety the Penaeus Vannamei - recently introduced in Asia. Taken together, both varieties account for more than 85% of the shrimp production in the main producing countries. In our cost-benefit analysis, we consider four scenarios. We estimate the surplus for shrimp producers, exporters and the government associated with each scenario for three different countries (India, Indonesia and Viet Nam). The four scenarios are as follows:

- *Baseline scenario*: no improvements in the current production process. OECD shrimp-importing countries do not control all consignments. A certain share of contaminated Asian shrimps can enter OECD markets.
- *Scenario 1*: no improvements in the current production process. Due to health and safety risks, OECD countries ban shrimp imports from Asian countries and the latter lose their main export markets.
- *Scenario 2*: Improvement in the production through the implementation of BMP programmes. The use of antibiotics in the production is banned and Asian governments reinforce quality controls and inspection before exports. OECD countries allow shrimp imports from Asian countries. However,

38. Other usual names for *Penaeus Vannamei* are whiteleg shrimp or Pacific white shrimp. Black tiger shrimps are also called giant tiger prawns or *Penaeus monodon*.

compared to scenario 1, production costs are higher (due to BMP programmes) and there are also inspection costs for the government.

- *Scenario 3*: Improvement in the production scheme (BMP Programmes) and changes in the type of shrimps produced. A more disease-resistant type of shrimp is now produced. We assume that this new type of shrimp account for 80% of the shrimp production. OECD countries allow shrimp imports from Asian countries. Compared to scenario 2, this last scenario involves a change in the production costs (costs of BMP programmes and new production costs related to the production of disease-resistant shrimps) and a change in the export revenues (new type of exported shrimps with a lower world price linked to the smaller size of the shrimps).

For each country and each type of production (Black Tiger shrimp and Vannamei shrimp), a perfectly competitive industry with price taking firms (small country) is assumed. The parameters of the supply functions depend on the scenario I with I={0, 1, 2, 3}. The subscript 0 refers to the baseline scenario. N_I farms choose Vannamei shrimps, while M-N_I farms choose Black Tiger shrimps

The model is built along the lines explained in OECD (2008). Since the analysis focuses on the producers' side, we first need to detail the profits for shrimp producers. Vannamei shrimp producing firms are choosing output to maximize profits under a scenario I[39]:

$$\pi_j^{V,I} = \lambda_{V,I} * p^V * q_j - a_{V,I} * \frac{\varepsilon}{1+\varepsilon} * q_j^{\left(\frac{1+\varepsilon}{\varepsilon}\right)} - K_{V,I} \text{ for } j=\{1,...,N\} \qquad (1)$$

Where $\lambda_{V,I}$ is the probability of entering the export market under the scenario I, p^V is the price paid to farmers and assumed constant across all scenarios, $a_{V,I}$ is the variable cost parameter of Vannamei shrimps, $K_{V,I}$ is the sunk cost linked amongst others to the firm's safety/quality investment and compliance with regulations, and ε is the (constant) price elasticity of supply. The probability $\lambda_{V,I}$ of entering the export market depends on the number of controls at the border and the precision of the test for detecting products. If the product is rejected at the border with a probability (1- $\lambda_{V,I}$), we assume that the production of shrimp is completely lost. There is no possibility to divest the products. The profit given by (1) is an *ex ante* profit before the realization of the inspections/controls at the borders with risk-neutral farmers. For Vannamei shrimps, the profit maximization yields isoelastic individual firm supply ($q_j = a_{V,I}^{-\varepsilon} * \left(\lambda_{V,I} * p^V\right)^{\varepsilon}$) functions which can be added up ($\sum_{j=1}^{N_1} q_j$) to yield the overall supply Q :

39. For reasons discussed below, we do not employ the quadratic cost functions used in OECD (2008), but cost functions consistent with isoelastic supply functions.

$$p_{V,I}^{S}(Q) = \frac{1}{\lambda_{V,I}}\left(a_{V,I} * \left(\frac{Q}{N_1}\right)^{\frac{1}{\varepsilon}}\right) \tag{2}$$

For any given price, p^V, the overall profits for the N_I farmers is

$$\pi_j^{V,I} = N_1\left[\left(\lambda_{V,I} * p^V\right)^{(1+\varepsilon)} * a_{V,I}{}^{-\varepsilon} * \frac{1}{1+\varepsilon} - K_{V,I}\right]. \tag{3}$$

Using the same methodology, the overall supply of Black Tiger shrimps by *(M-N$_I$)* farmers is

$$p_{B,I}^{S}(Q) = \frac{1}{\lambda_{B,I}}\left(a_{B,I} * \left(\frac{Q}{M-N_1}\right)^{\frac{1}{\varepsilon}}\right) \tag{4}$$

For a given price, p^B, the overall profits for the *M-N$_I$* farmers is

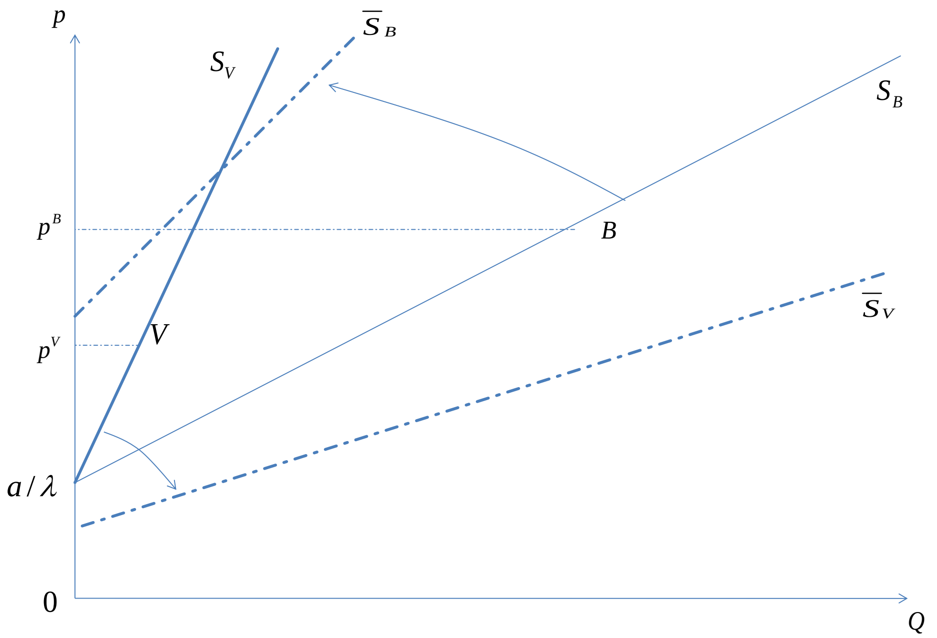
$$\pi_j^{B,I} = (M - N_1)\left[\left(\lambda_{B,I} * p^B\right)^{(1+\varepsilon)} * a_{B,I}{}^{-\varepsilon} * \frac{1}{1+\varepsilon} - K_{B,I}\right]. \tag{5}$$

Note that since prices are constant, the reward for the farmer comes in the form of steady demand.

For the four scenarios, the values of parameters $\lambda_{V,I}$, $a_{V,I}$, $K_{V,I}$, $\lambda_{B,I}$, $a_{B,I}$, $K_{B,I}$, of equations (2) to (5) vary. Figure B1 shows the overall supply (S_B) of Black Tiger shrimps and the overall supply (S_V) of Vannamei shrimps over one scenario with $\lambda_{V,I} = \lambda_{B,I} = \lambda$ (a scenario where a few producers are choosing Vannamei shrimps)[40]. The price is located on the vertical axis and the quantity is shown along the horizontal axis. For Black Tiger shrimps and their equilibrium price p^B, the overall gross profit (without taking into account sunk cost K_B) is given by area $(a/\lambda)Bp^B$. For Vannamei shrimps and their equilibrium price p^V, the overall gross profit (without taking into account sunk cost K_V) is given by area $(a/\lambda)Vp^V$.

40. For simplicity, this graphical representation uses linear supply curves.

Figure B1. Market equilibrium



The various scenarios change the incentives to adopt different methods of production and the supply curves. In particular, the higher $a_{B,I}$ or the lower $\lambda_{B,I}$, the higher is the incentive to switch to Vannamei shrimps and the higher the pivotal and increasing shift of the inverse supply $\overline{S}_B$ of Black Tiger shrimps toward the vertical axis in Figure B1 and the higher the pivotal and decreasing shift of the inverse supply $\overline{S}_V$ of Vannamei shrimps toward the horizontal axis. The new supply curves $\overline{S}_B$ and $\overline{S}_V$ depending on more favorable policies for Vannamei shrimps are represented by dashed lines on Figure B1.

Under the baseline scenario and scenarios 1 and 2, we assume that only Black Tiger shrimps are offered, namely N_I =0. For scenario 3, a large proportion of farmers choose Vannamei shrimps.

The baseline scenario is used for the initial calibration based on the supply elasticity. Overall supply under the baseline scenario is defined by $Q(p) = a_0^{-\varepsilon} * (\lambda_{B,0} * p)^{\varepsilon}$. With the observed quantity $\hat{Q}$ sold over a period, the average price $\hat{p}$ observed over the period, and the direct price elasticity for the supply ε obtained from econometric estimates, the calibration leads to the estimated value for the demand parameter equal to $a_0 = \lambda_{B,0} * \hat{p} * \hat{Q}^{-\frac{1}{\hat{\varepsilon}}}$ The supply and the equilibrium profit are thus characterized under the baseline scenario.

Under scenario 1 and 2, the parameter $\lambda_{B,I}$ decreases and the parameter $a_{B,I}$ increases in comparison with $\lambda_{B,0}$ and $a_{B,0}$. The values of these parameters are estimated with the World Bank report (World Bank, 2005).

Under scenario 3, the supply for the Vannamei shrimps is $Q_3(p) = a_3^{-\varepsilon} * (\lambda_{V,3} * p)^{\varepsilon}$. We assume that a share ω = 80% of producers switch to supply Vannamei shrimps as opposed to Black Tiger shrimps.

B3. Data

The empirical application focuses on India, Indonesia and Viet Nam. The choice has been motivated by two facts. First, they are among the top five world producers of shrimps and, second, they have not yet switched a large part of their farming production to disease-resistant Vannamei shrimp. In 2006, disease-resistant Penaeus Vannamei represented less than 45% of the aquaculture shrimp production in Indonesia and Viet Nam and was not produced in India.[41] On the other hand, traditional Black Tiger shrimp (Penaeus Monodon) still accounted for 43% of the aquaculture in Viet Nam, 43.5% in Indonesia and 99% in India, respectively (Figure B5 of the appendix). India, Indonesia and Viet Nam therefore represent ideal cases for the estimation of our last scenario (switch towards disease-resistant shrimps).

In what follows, we turn to description of data used for welfare estimations. All the calculations have been done in an excel spreadsheet that is available upon request. The spreadsheet has one sheet per country and allows modifying models parameters. The model is recalculated automatically using the new set of parameters.

Black Tiger and Vannamei production subject to OECD standards and requirements (Q)

As previously mentioned, we focus only on aquaculture production. The division of production between aquaculture and capture varies significantly from one country to another. According to FAO statistics, in 2006, the share of aquaculture in global shrimp production is 26.9% in India, 62.5% in Indonesia and 78.1% in Viet Nam. Furthermore, we assume that only the production exported to the OECD countries is affected by importing countries' standards.

Unfortunately, the trade statistics do not provide exports by species (Black Tiger *vs*. Vannamei) and by type of production (aquaculture *vs*. capture). Information by species and type of production is only available in the production statistics. Therefore, to obtain an estimate of the Black Tiger and Vannamei production subject to OECD shrimp-importing countries' standards, some approximations using trade and production statistics are necessary. We proceed as follows (Table B1). First, we calculate the share of the total production

41. The exact share is 41.7% in Indonesia and 43% in Vietnam. By comparison, China and especially Thailand have almost completely replaced their production of Black Tigers by *Penaeus Vannamei*.

(aquaculture and capture) exported to OECD markets and, second, we assume that this share is the same for aquaculture production of each shrimp species.[42]

Table B1. Black Tiger aquaculture production subject to OECD standards, 2006

	Exports to OECD (tonnes)	Total production (tonnes)	Share production exported to OECD countries (%)	Aquaculture production Black Tiger (tonnes)	Aquaculture production of Black Tiger subject to OECD standards (tonnes)*
India	109 194	536 072	20.4	142 967	29,165.3
Indonesia	116 281	543 943	21.4	147 867	31 643.5
Viet Nam	117 250	446 900	26.2	150 000	39 300.0

* Authors' calculations based on the share of the total production exported to OECD countries and the volume of aquaculture production (see text).

Sources: Trade data, UN Comtrade; Production, FAO.

Price received by farmers (p^B and pV)

Data on shrimp prices come from the FAO. An important price difference exists between Black Tiger and Vannamei. Black Tiger's price is higher than the one of Vannamei, mostly due to the size of shrimps: Vannamei shrimps are smaller than Black Tiger and their price is therefore lower.

Supply elasticity (ε)

Data on supply elasticity come from the International Institute for Fisheries Economics and Trade (IIFET, 2004). Elasticities are specific to each country. Unfortunately, they are for the aquaculture fish production and are not specific to aquaculture shrimp production. $\varepsilon = 1.33$ for India, 0.28 for Indonesia and 0.37 for Viet Nam.[43]

Probability of entering the export market (λ)

In our calculation, due to data constraints, we assume that the probability of entering the OECD market is the same for Black Tiger and Vannamei.

In the baseline scenario, to determine this probability we combine two elements: the probability of being controlled and the test precision. The probability of being controlled we set at 20% based on the report made by the Southern Shrimp Alliance (2007). The report states that:

42. In other words, if 20.4% of Indian shrimp production is exported to OECD markets, we assume that 20.4% of Indian Black Tiger aquaculture production is exported to OECD markets as well as 20.4% of Indian Vannamei aquaculture production.

43. Note the substantial difference between the elasticity in India on the one hand, and those for Indonesia and Vietnam. Unfortunately, IIFET (2004) does not provide further details on the reasons behind such a difference but it is likely to be linked to differences in the fish produced in the three countries – a factor that should not cause supply elasticities for shrimps to be different. The level of the supply elasticity will be subject to discussion below.

> "Stringent follow-up inspections are conducted both at the EU's border, currently 20% of seafood products are inspected, and regularly at the exporters' facilities. Japan has a strict risk-based system that is reinforced by high inspection rates — currently 25% for shrimp imports — as well as certification requirements and significant penalties for noncompliance. Canada imposes a minimum standard inspection rate of 15% for all imported seafood products and strict licensing requirements for importers." (Southern Shrimp Alliance, 2007, pp.6-7)

The test precision[44] is assumed to be 50%. When combining both elements, we obtain the probability of entering the OECD market in the baseline scenario equal to 0.9. In scenario 1, this probability is equal to 0 due to the import ban. In scenarios 2 and 3, we set this probability to 1, assuming that, following the implementation of BMP programmes (which impose more controls by Asian exporters and governments before the exports), OECD shrimp-importing countries reduce their own controls, as it is observed in practice. For example, a bilateral agreement established between Canada and Viet Nam in July 2006 required Vietnamese health officials to inspect and certify shrimp exports bound for Canada for banned chemicals and antibiotics. In return, no more than 5% of Vietnamese-certified shipments would be tested upon arrival by Canadian authorities (Southern Shrimp Alliance, 2007). The marginal cost variation, for scenarios 2 and 3, comes from the World Bank (2005, Tables 8-9, pp.18-19). Table B2 sums up the parameters used for the estimations.

Table B2. Values of parameters under the different scenarios

	Baseline scenario	**Scenario 1**	**Scenario 2**	**Scenario 3**
	No changes in current production scheme	**No changes in current production scheme; trade ban**	**BMP measures**	**BMP measures and disease-resistant shrimp**
Probability entering OECD markets	$\lambda_{B,0} = 0.9$	0	1	1
Marginal cost variation (%)	0	0	10	-33
Price (USD/kg)	$p^B = 18.73$	$p^B = 18.73$	$p^B = 18.73$	$p^B = 18.73$ $p^V = 9.92$

44. More precisely, the likelihood of a tested consignment being rejected by the authorities of the importing country. This probability is defined as [probability of a consignment being contaminated * probability of a contaminated consigment being detected as contaminated if tested]. As neither of these two probabilities is observed, we do not make explicit assumptions on these but limit ourselves to the 50% assumption above.

B4. Results

Table B3 provides the impact on farmers' profits in aquaculture under different scenarios for the year 2006.

Table B3. Overview of scenario results relative to base (exporters to OECD countries only)

	Absolute changes (tonnes or USD)			Relative changes*		
	Scenario			Scenario		
	1 Import ban	2 BMP programmes	3 BMP and resistant Vannamei shrimps	1	2	3
Vietnam						
Change in production	-39 300 000	146 414	-1 478 141	-100,0%	0,4%	-4,7%
Change in gross profits	-483 793 883	55 757 539	-170 071 115	-100,0%	11,5%	-43,9%
Change in OECD imports	-35 370 000	4 076 414	1 665 859	-100,0%	11,5%	5,9%
Indonesia						
Change in Production	-31 643 500	89 173	-905 920	-100,0%	0,3%	-3,6%
Change in Gross Profits	-416 929 796	47 631 013	-144 362 907	-100,0%	11,4%	-43,3%
Change in OECD imports	-28 479 150	3 253 523	1 625 560	-100,0%	11,4%	7,1%
India						
Change in Production	-29 165 300	392 468	-3 708 586	-100,0%	1,3%	-15,9%
Change in Gross Profits	-211 105 193	26 612 550	-85 330 889	-100,0%	12,6%	-50,5%
Change in OECD imports	-26 248 770	3 308 998	-1 375 362	-100,0%	12,6%	-6,5%

*) Relative changes for scenario 3 are for producers switching to Vannamei production only.
Pro-memory: Gross Profits ignore sunk costs K that might change across scenarios. Regulatory/monitoring costs are not considered.

The loss under scenario 1 is very large compared to the baseline scenario, since the export market is fully blocked by the ban in importing countries: production related to exports to the OECD is assumed to stop, with no alternative markets assumed to exist. In scenario 2, the increase in production costs is more than compensated by the higher probability of entering the OECD markets, which result in increased net revenues. Despite the lack of precise data, this result underlines the incentive for farmers to improve their process of production for complying with safety rules, and for ensuring full access to the export markets.

Results for the third scenario suggest that a switch to Vannamei production is unprofitable for the average farmer. This result, which is linked to strong decline in profits for all three countries, can be explained by the fact that the reduced production costs (-30%) and higher probability of entering the OECD markets are outweighed by the significant cut in the shrimp price (-47%). This overcompensation is even more important given that (variable) costs in the baseline only represent a relatively small share of gross revenues (between 22% and 57%, depending on the country). In addition, gross revenues not only decline due to lower prices but also because of reduced output. In consequence, the switch to Vannamei production would cost producers between 43% and 51% of their baseline profits.

A major uncertainty in this analysis is the level of the supply elasticity in the three countries. As noted above, in the absence of more specific parameters the different values stem from the IIFET (2004) study which is on fish production rather than on shrimps. Differences in the supply elasticities across countries are likely to partly be related to different fish produced in the countries, a factor that should not impact shrimp production. Indeed, as a simple sensitivity analysis shows, the differences in relative profit changes (and, in fact in relative changes of production and OECD imports, too) are caused by the different elasticities used and would disappear if the same value were used for all three countries. Absolute changes of course still differ given the different baseline data used. At the same time, however, the results also show that the value of the elasticity does not change the results in principle, with the exception of the change in OECD imports where the sign changes for scenario 3.

The initial probability of Black Tiger shrimps entering the OECD markets obviously also impacts on the relative profitability of production changes aiming at securing full access to importing countries. A sensitivity analysis shows that decreasing the corresponding parameter $\lambda_{B,0}$ from 0.9 to 0.85 in the baseline has the expected positive impact on profit changes for both scenarios 2 and 3 in that it almost doubles the profit increases for the former, and slightly reduces the losses in the latter scenario. However, the important decline in the achievable output price still makes the switch to Vannamei production unprofitable unless, of course, exporters are threatened by a complete import ban for Black Tiger shrimps.

A similar sensitivity analysis was done to see the impact of the cost changes related to the adoption of BMP and/or the switch to disease-resistant Vannamei shrimps. A lower increase in costs due to BMP increases the profit gains for all producing countries: unchanged costs would make profit gains due to the improved market access increase by between 26% and 121% for the three countries compared to the situation where costs increase by 10%. The higher price elasticity makes Indian profit changes particularly sensitive to alternative assumptions on the costs of BMP. Similarly, a cost reduction of 40% related to the switch to Vannamei (as opposed to 33% assumed in the original scenario 3 above) would leave shrimp production quantities almost unchanged despite of the significant price drop. Import quantities by OECD countries would consequently increase, as none of the Vannamei consignments would be rejected by the testing authorities. Profits, however, would still decline substantially due to the lower shrimp price, though with about -42% compared to the baseline somewhat less drastically than with the original cost savings.

Finally, if the price difference between Black Tiger and Vannamei – some 47% in the scenario 3 above – were smaller, this would have major implications for the profitability of a switch to Vannamei. Indian producers with the high supply elasticities would switch without any profit losses provided the price drop would be no more than 28.4%, while producers in Viet Nam and Indonesia would see unchanged profits if price reductions were less than 19.2% and 17.5%, respectively.

B5. Extensions

As noted above, the analysis assumed isoelastic supply functions rather than the linear supply functions used in the original framework laid out in OECD (2008). This change is important in the context of the present case: linear supply functions, and hence quadratic cost functions, are characterized by an intercept with the ordinate (the price axis) that becomes negative if the point estimate of the supply elasticity is less than unity. Given that in the cases of Viet Nam and Indonesia, the price elasticities of shrimp supply were assumed to be significantly smaller than one, this negative intercept becomes large, suggesting a significant negative linear component of variable costs. This negative cost component, however, causes calculated profit changes for scenario 2 (11% higher revenue due to improved market access, 10% increase in the quadratic part of variable costs) to shrink rather than to increase. The opposite would be found for scenario 3. It is therefore important for scenarios involving changes in production costs to employ a model that avoids negative intercepts with the price axis.[45]

In order to be more accurate in the estimations and/or to fit different regulatory problems, some extensions may be integrated into the model presented here. For example, the framework of section 3 can be easily extended by taking into account the consumers from OECD countries by characterizing their demands depending on the food safety, similarly as it was done in the cheese case study.Furthermore, control costs for exporters and government under scenarios 2 and 3 could also be added.

B6. Conclusion

This study analyses the effects of border measures protecting human health against contaminants found in shrimps. In particular, it looks at the incentives major Asian producers may have to change their production practices in order to comply with importers' ban on antibiotic use. The results indicate that if OECD countries were to ban imports for health reasons then indeed a substantial profit incentive exists to adopt improved production methods (BMP). Indeed, the 10% probability of a consigment being rejected due to border protection under normal production methods already should create a clear incentive for the adoption of BMP that would eliminate that risk. In contrast, unless an import ban would threaten the production of Black Tiger shrimps in the three countries considered, the switch to the production of the desease resistant Vannamei variety would

45. This, however, poses another question that would deserve further elaboration: There are many more than just one (the isoelastic) functional forms that meet the above criteria. While it seems plausible to assume that results for the different scenarios analyzed here would not change fundamentally with other functional forms meeting the above criteria, the reader should be aware of this issue, and more work on this might be warranted. It should be noted, however, that most other functional forms require more data to be calibrated properly – here, we used only base year prices, quantities and a supply elasticity taken from the literature, and even the supply elasticity needed to be borrowed from studies on other production sectors than the one analyzed here. Finding the additional information required to calibrate more flexible functional forms is likely to be challenging.

significantly reduce profits in all three countries, given the large price discount for this smaller product.

Sensitivity analyses show that these principal results are robust with respect to the actual supply elasticity used. On the other hand, the size of the impact strongly depends on changes in production costs following the change in production methods. The study adopted an aggregate view of the shrimp industry and therefore did not account for heterogeneity of farms. The cost of BMP implementation for small and big farms would obviously not be the same and for some farms may be prohibitive. Depending on the sunk or variable costs being prohibitive, trade may be affected at both, the intensive and extensive margins.

BMP implementation is also subject to a free-riding problem. Producers could hope that other producers adopt BMP that would result in reduced import inspections, however, they themselves may not want to apply improved production methods, because of (high) implementation costs.

The strong reduction in profits found for producers switching to disease-resistant Vannamei shrimp production is consistent with intuition: lower production costs and increased market access are overcompensated by the much lower price achieved for the smaller Vannamei shrimp compared to the larger Black Tiger. However, it raises the question on why some other countries, such as China and Thailand, have already switched to Vannamei. Unless this change had been forced either by large retailers in major importing countries (which would be equivalent to an improved price ratio between Vannamei and Black Tiger) or major problems in the production of other species including Black Tiger, it is likely that cost savings (*e.g.* through scale effects) were more significant and price differentials less pronounced than assumed in this analysis. These parameters have been explored in the sensitivity analyses above and found to be important drivers of the results for scenario 3, requiring more empirical research for better specification.

Stringent standards in OECD countries could also impact on the structures of the shrimp industries if they require significant investments. Smaller farms not able to meet the quality requirements could end up being excluded from the important export market, resulting in fewer and bigger farms and adverse consequences for smallholders and rural livelyhood. There may, however, be specific assistance programmes targeted towards small farms in order to avoid or reduce those effects.

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Appendix B1.

Descriptive Statistics

Appendix Table B1. Shrimp imports

Year	World imports (thousand tonnes)	World imports (million USD)	Share OECD countries (volume-based imports, %)	Share OECD countries (value-based imports, %)
1996	1 036.96	8 544.87	94.5	96.3
1997	1 073.42	8 744.27	89.5	94.5
1998	1 120.99	8 818.15	90.7	95.2
1999	1 179.64	8 669.55	90.0	93.9
2000	1 304.00	9 954.50	85.7	92.6
2001	1 425.77	9 373.94	85.4	92.5
2002	1 474.16	8 721.78	84.3	92.1
2003	1 616.45	9 731.19	83.8	92.1
2004	1 681.20	10 007.51	83.1	90.5
2005	1 684.49	10 075.89	83.9	91.0
2006	1 752.45	10 909.65	84.7	91.5

Source: UN Comtrade.

Appendix Table B2. OECD shrimp imports: share of each country (2006)

	Share of OECD imports (%)
EU countries (OECD members only)	40.3
United States	31.6
Japan	19.8
Canada	2.4
South Korea	2.3
Australia	1.9
Iceland	0.6
Switzerland	0.4
Mexico	0.3
Norway	0.3
New Zealand	0.2
Turkey	0.1

Value-based imports. OECD Members' share in total EU(27) imports was 99.3%
Source: Comtrade.

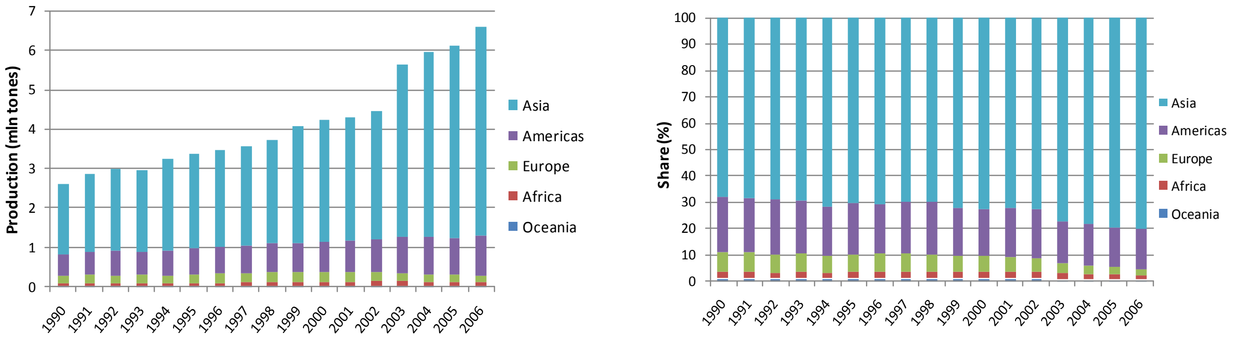
Appendix Table B3. Top ten shrimp exporters to OECD (2006)

	Share in OECD imports (%)
Thailand	11.7
Viet Nam	10.8
Indonesia	9.4
India	8.5
Ecuador	6.6
China	6.0
Bangladesh	4.5
Argentina	3.8
Mexico	3.4
Malaysia	2.3
Total top ten exporters	67.0
Total top five world producers*	46.4

The top five world producers are China, Thailand, Indonesia, India and Viet Nam (see table above). Value-based imports.

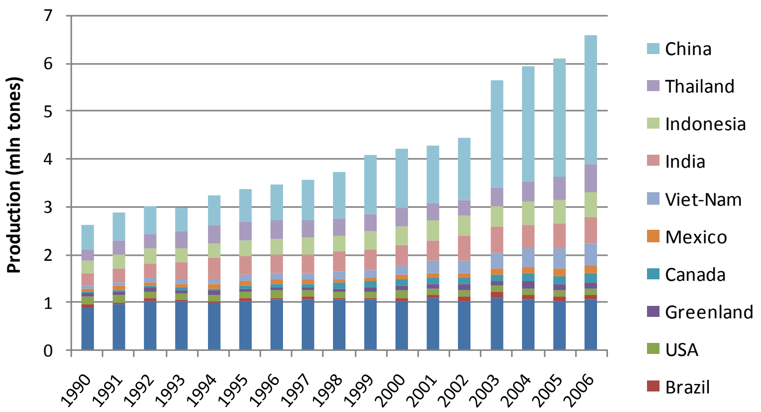
Source: Comtrade.

Appendix Figure B1. World shrimp production (million tonnes) and continents' share (%)



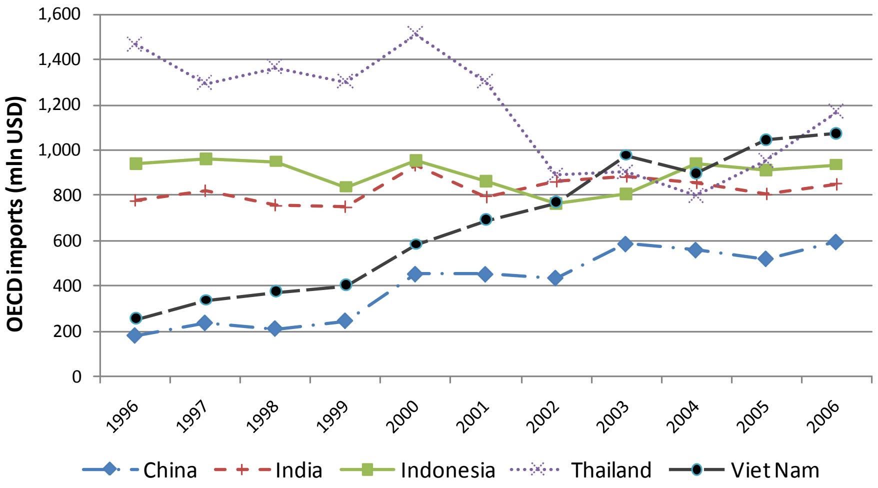
Production includes aquaculture production and capture production.
Source: Authors' calculation based on FAO http://www.fao.org/fishery/statistics/global-production/en

Appendix Figure B2. Top ten shrimp producers



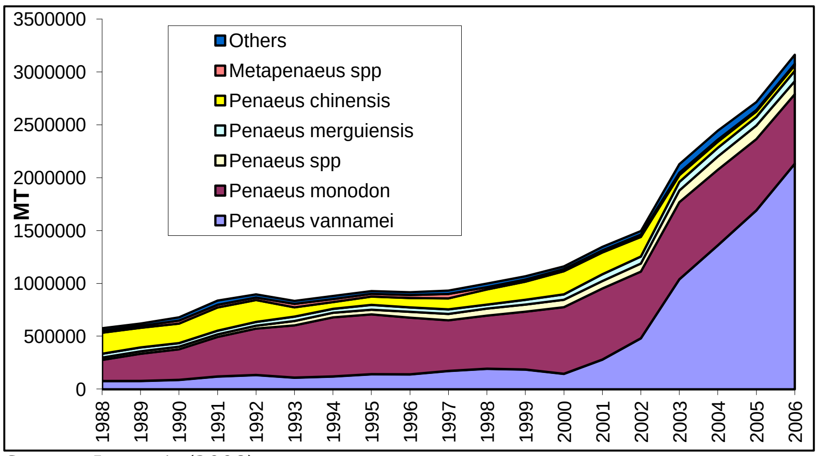
Production includes aquaculture production and capture production.
Source: FAO http://www.fao.org/fishery/statistics/global-production/en

Appendix Figure B3. OECD imports from top five shrimp producers



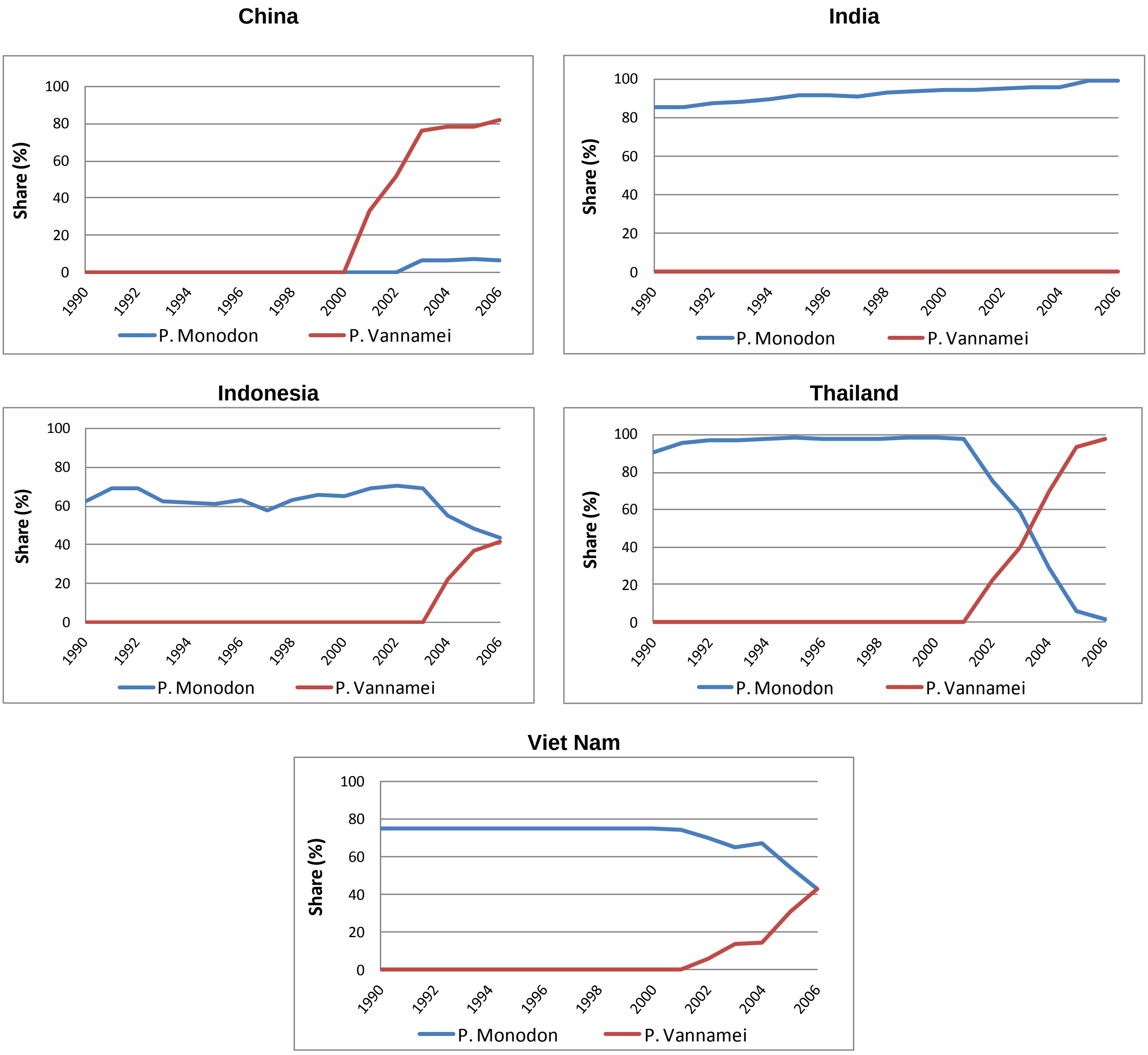
Value-based imports.
Source: Comtrade.

Appendix Figure B4. Shrimp aquaculture, by species



Source: Josupeit (2008).

Appendix Figure B5. Shares of Penaeus Monodon and Penaeus Vannamei in total shrimp aquaculture production, by country



Source: FAO http://www.fao.org/fishery/statistics/global-aquaculture-production/en.

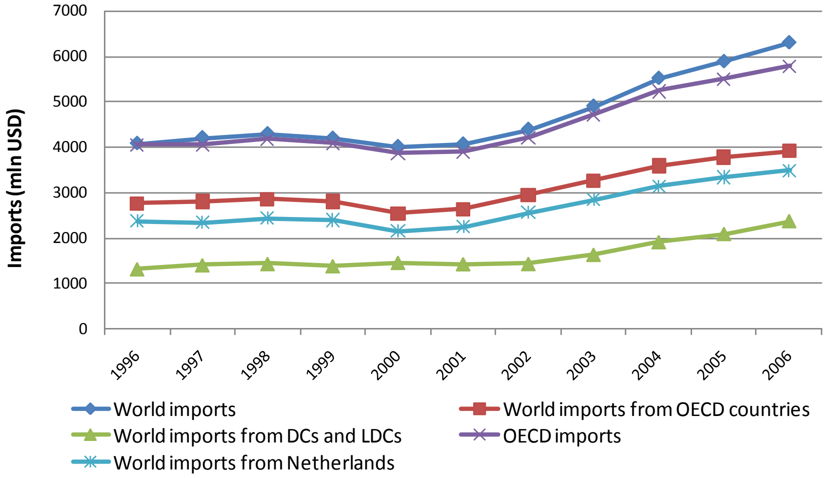
Part C.

A cost-benefit analysis for the assessment of European measures against the introduction and spread of harmful organisms intercepted on cut flowers

Are Norway and Switzerland the countries where people offer the most flowers? They are certainly the two countries where per capita expenditures on flowers are highest. In 2006, per capita consumption reached EUR 82 in Switzerland and EUR 62 in Norway, followed by the Netherlands and Japan (EUR 54), the United Kingdom (EUR 47), and Denmark (EUR 46).[46]These numbers show that European Union member states are among the most important consumers of flowers within the OECD area.

Since the beginning of the 2000s, international flower trade has shown a strong development. Between 2000 and 2006, world imports of cut flowers increased by 57.2% from 4 016.2 to 6 313 million USD. Most of the demand occurred in OECD countries (91.7% of world imports in 2006).[47] Figure C1 shows that most imports are into OECD countries (62% in 2006). However, this high share results mainly from the specific situation of Netherlands: in 2006, more than half of world imports of cut flowers (55.1%) originated from this single country.

Figure C1. Imports of cut flowers (million USD)



Source: UN COMTRADE.

46. Source: http://www.flowercouncil.org/uk/holland/facts_figures/.

47. Appendix Table A.1 provides data on imports of cut flowers by OECD country in 2006. The top ten world importers of cut flowers are (in decreasing order): Germany, United Kingdom, United States, Netherlands, France, Russia, Japan, Italy, Switzerland, and Belgium. Data have not been adjusted for re-exports due to lack of necessary information.

Cut flower exports from developing and least developed countries (DCs and LDCs) have increased over the last decade and reached USD 2 375.9 million in 2006.[48] In 2006, seven of the top ten countries of origin of cut flowers imports were DCs (Table C1). The growth in importance of DC in exports of cut flowers could be explained by several factors. First, many DCs have favourable climate conditions for cut flower production. Flower growing has also an advantage to be a complement to more traditional exports, while the access to markets in developed countries provides powerful financial incentives. Furthermore, many developing countries are attempting to diversify their export base in order to gain new sources of income and foreign exchange and thus to reduce their exposure to price volatility that affect international markets.

Table C1. Top ten origin countries of cut flower imports in 2006 (million USD)

Country	Value of cut flowers imported from this country
Netherlands	3 480.8
Colombia	853.2
Ecuador	449.1
Kenya	421.2
Israel	144.9
Thailand	91.7
Italy	81.9
Malaysia	68.0
Spain	63.7
China	48.2

Source: UN COMTRADE.

As trade in cut flowers has expanded, a growing number of non-tariff measures (NTMs), aimed at regulating production and trade, has been implemented. Such measures can be classified into three categories: (i) sanitary and phytosanitary measures, (ii) fair trade and labour standards, and (iii) environmental and eco labels.

The latter two categories comprise non-mandatory, private standards imposed by producers' associations and global retailers of cut flowers. Examples of certifications in the horticultural sector are the Florverde label in Colombia, the Kenya Flower Council Certification, the Flower Label, or the MPS labels.[49]

Part C focuses on SPS measures applied by public authorities. More specifically, it deals with the impact of the European protective measures, aimed at limiting the introduction and the spread of some invasive species, on cut flower production and trade. After repeated interceptions of various invasive species on fresh cut flowers, the EU planned in 2001 to reinforce its inspection procedures.

48. This rise in trade has been associated with an impressive growth in production. A significant part of the production is made by affiliates of multinational firms.

49. http://www.florverde.org/, www.kenyaflowers.co.ke/, http://www.fairflowers.de/, or http://www.my-mps.com/asp/page.asp?sitid=436.

However, following EU notification to the WTO, Ecuador and Israel (supported by Kenya) raised a trade concern in the WTO SPS Committee. These countries feared that changes in the inspection procedures could affect their exports of cut flowers to the European market.

To assess the economic consequences of the EU measures, the analysis looks at the supply side and estimates the potential losses and gains for European producers, foreign exporters and governments, and European authorities. Part C applies a cost-benefit framework outlined in OECD (2008). Given the focus of Part C, the base framework is extended to include several additional features in the supply functions. In particular, foreign producers' supply function has several additional parameters to take into account the probability of being inspected by the importing country, the probability of passing successfully the inspection tests and possible product quality deterioration following the duration of the inspection process. Domestic producers' supply curve is augmented to include the probability of yields loss due to contamination coming through imports of infested products.

Four different scenarios are analysed. The first is the baseline scenario that replicates the current situation of low rate of inspection. Inspection measures are consequently strengthened in the second and third scenarios; however, flower producers do not change their production scheme. The third scenario accounts also for a potential deterioration of the quality of flowers due to time spent during inspection. In the last, fourth, scenario, it is assumed that foreign producers adjust their production to satisfy European requirements and EU countries check only a part of consignments.

The empirical application focuses on the imports of roses by the European Union (EU27). As already mentioned, EU member states are among the main importers of flowers, while roses are one of the main traded varieties of flowers. Moreover, compared to other flower varieties, there is a large literature providing useful data on imports and inspection of roses by the EU.

Part C underscores the profit implications for foreign and EU producers under different scenarios. The results of the simulations suggest that the increase of inspection costs for the EU outweigh the benefits from reduced infestation for the EU producers. Tighter inspection leads also to losses to foreign suppliers, especially if inspection coincides with depreciated quality of product due to time spent during the inspection. In addition, the analysis shows that improving production methods in exchange for reduced inspection tightness would also lead to diminished profits for foreign suppliers because of higher production cost.

Part C proceeds as follows. The trade concern raised in the SPS Committee by Ecuador and Israel, and supported by Kenya, against European measures on cut flowers is briefly surveyed in section C1. Section C2 specifies the cost-benefit model used. Data and calibration are described in section C3. Section C4 provides results and discusses some extensions. Section C5 concludes.

C1. Trade concern raised in the SPS Committee against European measures on cut flowers

This trade concern was brought to the SPS Committee's attention for the first time in 2001 (meeting held on 31 October – 1 November 2001). The issue was raised by Ecuador and Israel, supported by Kenya, and originating from the European notification (G/SPS/N/EEC/131)[50] dealing with protective measures against the introduction and the spread within the EU of organisms harmful to plants or plant products.

This notification amended the EU Council Directive 2000/29/C, which regulated the plant health regime and listed plants and plant products that had to be inspected before their entry into the EU. Following the continuing interceptions of invasive species on certain commodities, including cut flowers, the EU decided to strengthen its inspection procedures at ports of entry. The amendment covered four harmful organisms: *Amauromyza Maculosa, Bemisia Tabaci* (non-European populations), *Liriomyza Sativae* and *Thrips Palmi*. The entry into force of the new inspection measures was planned for 1 January 2002. Most of the cut flower imports were not hitherto subject to plant health checks.

Following EU notification, Ecuador asked for clarification on the scientific grounds for the measure, the risk assessment, methods to be used at entry ports, special treatment for developing countries, and possible alternative measures. Israel highlighted that time spent in inspection could affect the quality and the prices of delivered flowers.

The entry into force of EU measures was postponed to April 2003. At the SPS Committee meeting held on 7-8 November 2002, Israel again raised concerns about EU protective measures and stated that until pest risk analysis was not finalized, these measures should be temporary. The EU agreed to enter into bilateral consultations with Israel and Kenya.

On 1 April 2003, EU measures entered into force. At the SPS Committee meeting held on 2-3 April 2003, Israel claimed that EU protective measures would force exporting countries, and especially developing ones, to undertake costly and lengthy investments in new infrastructure (shift in production from open field sites to greenhouses). Furthermore, Israel voiced doubts on the capacity of the EU to distinguish between European and non-European varieties of Bemisia Tabaci. Kenya also expressed concerns on the adverse effects of EU measures on cut flower exports and emphasized the slow progression of its bilateral consultations with the EU on technical assistance on capacity building. In its answer, the EU mentioned that further bilateral consultations could take place. This trade concern was not further discussed during the next SPS Committee meetings.

One reason the issue was not followed up in the SPS committee may be the EU Directive 2002/89/EC which introduced reduced plant health checks for products satisfying certain conditions. These conditions are detailed in EC

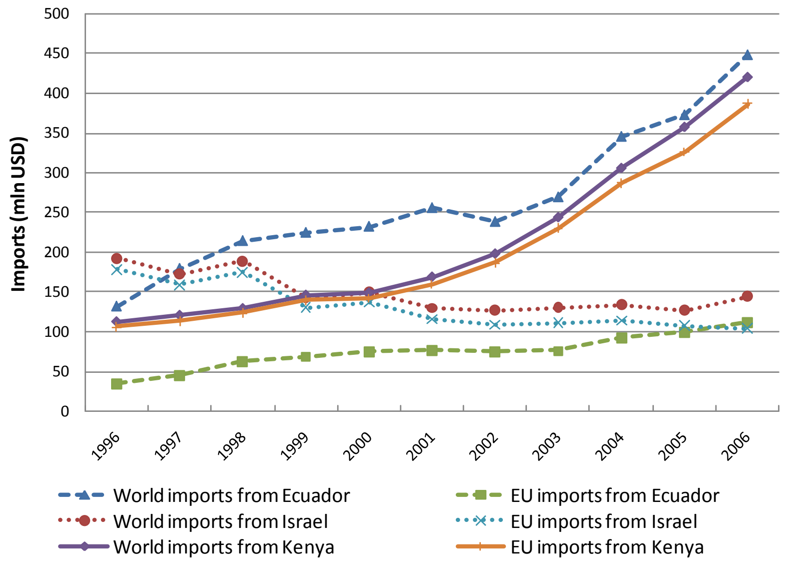
50. See also EU Directive 2002/36/EC.

Regulation 1756/2004.[51] If these conditions are satisfied, the EU Commission decides a minimum percentage of checks. Reduced checks are specific to each bilateral relationship between the EU and a third country and each product. EU countries can then inspect any percentage of imports between this minimum value and 100%. Since 2005, reduced checks have been decided for 53 bilateral trade relationships of plants, plant products or other objects, of which 16 are cut flowers. This list was revised in 2007.[52]

What is the importance of the European market for the complainant countries? Figure C2 reports world and European imports of cut flowers coming from these three countries. Figure C3 presents the EU[53] share in world imports. Both figures suggest that the EU is the major trade partner of Kenya and Israel. Over the period 1996-2006, EU imports of Kenyan cut flowers represented more than 90% of world imports. For Israel, the share is also high although decreasing. It was 71.8% in 2006, while it was between 85% and 93% from 1996 to 2005. The EU market is less important for Ecuador: between 1996 and 2006, EU imports represented 25-32% of world imports of Ecuadorian cut flowers.

Figure C2 also shows a strong increase in world and European imports of cut flowers from Ecuador and Kenya (+240% for world imports from Ecuador and +277% for world imports from Kenya).[54] World and EU imports of Israeli cut flowers decreased over the last decade (respectively by 24.7% for world imports and 41.7% for EU imports).

Figure C2. Cut flower imports from Ecuador, Israel and Kenya (million USD)



Source: UN COMTRADE.

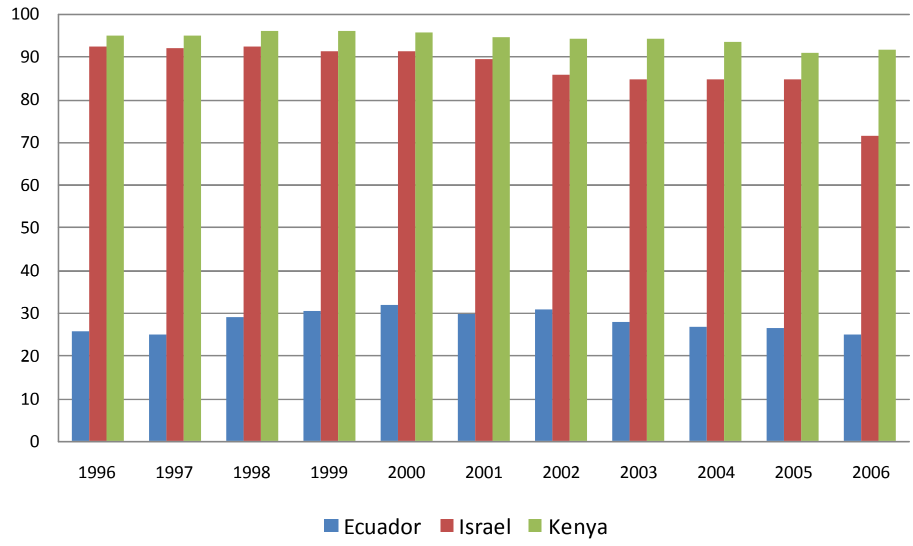
51. See also Surkov *et al.* (2007) for a detailed description of this Regulation.

52. http://ec.europa.eu/food/plant/organisms/imports/recommended_products.pdf

53. Data for EU27.

54. Between 1996 and 2006 European imports of Ecuadorian cut flowers rose by 228%, while EU imports from Kenya increased by 263.1%.

Figure C3. EU imports as a percentage of world cut flower imports from Ecuador, Israel and Kenya (%)



Source: UN COMTRADE.

C2. Cost-benefit framework

The study estimates potential losses and gains associated with the new European legislation for countries that raised (Ecuador and Israel) or supported (Kenya) the issue in the WTO SPS Committee.[55] The focus is on roses imported from these three countries by the EU. In addition to the costs and benefits for the exporting countries of cut flowers, the assessment also includes inspection costs for the EU.

Four different (hypothetical) scenarios are considered that evaluate the surplus for foreign producers, foreign exporters and both the foreign and the EU governments associated with each scenario.

- *Baseline scenario*: Current situation. Most of cut flower imports are not subject to plant health checks. A certain share of contaminated cut flowers can therefore enter the EU market.
- *Scenario 1*: Strengthening of the EU inspection procedures at the entry ports. On the production side, Ecuador, Israel and Kenya do not change their production conditions. Therefore, cut flower shipments contaminated with harmful organisms are rejected by EU authorities except if the inspection test is false (*i.e.* if the inspection procedure does not detect the harmful organisms present on roses).
- *Scenario 2*: Same as scenario 1, but with the inclusion in the calculation of the time spent in inspection. Flowers are perishable and the delays associated with

55. Using appropriate data, the estimation of losses and gains could easily be done for other countries that also export cut flowers to the EU and that could potentially be affected by the new EU regulation.

inspection may impact their quality. In that case, foreign producers will receive a lower price for their flowers.

- *Scenario 3:* Exporting countries have adapted their production (greenhouse production). EU now proceeds to reduced checks. However, compared to previous scenarios, production costs are higher (due to a shift in production from open field sites to greenhouses). Compared to scenarios 1 and 2, inspection costs are now reduced for the EU.

As mentioned before, it is the supply side that the analysis is focused on. Given that the new EU legislation concerns foreign producers and has consequences on domestic ones, both need to be accounted for in the model.

The supply of foreign producers will crucially depend on the inspection process. Let λ, $0 \leq \lambda \leq 1$ be the probability with which a consignment of flowers enters the importing country's market. This probability depends on a number of factors. Let σ be the probability of a consignment to be non-contaminated, then $(1-\sigma)$ is the probability with which the producer offers contaminated products entailing a damage for the importing country. A foreign producer's shipment has a probability γ of being inspected when imported. Inspection provides information about the products safety at a cost *C* for the importing country. Moreover, the inspection procedure is subject to a diagnostic error. Let ψ_H be the probability of a non-contaminated product to be detected as a non-contaminated product (*i.e.* correct positive test) and ψ_L the probability of a contaminated product to be detected as a non-contaminated product (*i.e.* false positive test), where $0 \leq \psi_L, \psi_H \leq 1$. Then the probability λ of a consignment to enter the import country's market is given by $\lambda = (1-\gamma) + \gamma * [\sigma * \psi_{\mathrm{H}} + (1-\sigma) * \psi_{\mathrm{L}}]$. The analysis focuses on the semi-imperfect inspection case, *i.e.* non-contaminated products is never falsely detected as being contaminated, but there is a non-zero probability that a contaminated products remain undetected ($\psi_L > 0$ and $\psi_H = 1$).[56] In consequence, the calculation simplifies to $\lambda = (1-\gamma) + \gamma * [\sigma + (1-\sigma) * \psi_{\mathrm{L}}]$, with the term in squared brackets representing the probability of a consignment passing the inspection.

For simplicity, it is assumed that results of inspection are clearly communicated to markets, middlemen and consumers. The market's expectation about the seller's quality depends on the inspection results. If a foreign producer passes an inspection, then the buyers update their expectation about contamination. Once the inspection is passed, the foreign producer receives a per-unit price p^A.

56 The supply inspection is imperfect when $0 < \psi_L, \psi_H < 1$ and perfect when $\psi_L = 0$ and $\psi_H = 1$.

Given the probability of a foreign producer passing the inspection successfully, the probability of contaminated products entering the market, leading to a damage to the importing country's producers, can be derived.[57]

We assume cost functions consistent with isoelastic supply functions: For a foreign producer *i* with an output q_i , the cost function is

$$c_i = a_i * \frac{\varepsilon_i}{1+\varepsilon_i} * q_i^{\frac{1+\varepsilon_i}{\varepsilon_i}} + K_i$$

where a_i is the variable cost parameter, ε_i is the price elasticity of the producer's supply, and K_i is the sunk cost linked amongst others to the firm's market entry and compliance with regulations. Since foreign cut flowers producers are relatively small in general, they are assumed to be a price takers and therefore the expected profit of one firm is

$$\pi_i = \lambda_i * p^A * q_i - a_i * \frac{\varepsilon_i}{1+\varepsilon_i} * q_i^{\left(\frac{1+\varepsilon_i}{\varepsilon_i}\right)} - K_i ,$$

where

$$\lambda_i = (1-\gamma) + \gamma * [\sigma_i + (1-\sigma_i) * \psi_{\mathrm{L}}]$$

The profit maximization yields individual firm supply functions

$$p_i^S(q) = \frac{1}{\lambda_i} * a_i * q^{\frac{1}{\varepsilon_i}}$$

By assuming M identical foreign producers $M * q_i = q$, their supply functions can be added up to yield total foreign inverse supply

$$p_F^S(q) = \frac{1}{\lambda} * a * \left(\frac{q}{M}\right)^{\frac{1}{\varepsilon}}$$

The overall profits for foreign producers are given by

$$\pi^F = M\left[\left(\lambda * p^A\right)^{(1+\varepsilon)} * a^{-\varepsilon} * \frac{1}{1+\varepsilon}\right] - K$$

Additionally, under scenario 2, producers receive a lower price if their products are inspected. The price reduction is captured by a reduction factor $\rho <1$ that depends on the inspection length. In this case, the expected profit of a foreign producer *i* is

$$\pi_i = \lambda_i^* * p^A * q_i - a_i * \frac{\varepsilon_i}{1+\varepsilon_i} * q_i^{\left(\frac{1+\varepsilon_i}{\varepsilon_i}\right)} - K_i$$

57. In this case, we do not consider the consumers' loss in the importing country incurred through possible changes in the price of cut flowers.

where[58]

$$\lambda_i^* = (1-\gamma) + \gamma * [\sigma_i + (1-\sigma_i) * \psi_{\mathrm{L}}] * \rho$$

Profit maximization yields individual firm supply functions

$$p_i^S(q) = \frac{1}{\lambda_i^*} * a_i * q^{\frac{1}{\varepsilon_i}}$$

The aggregated supply and the overall profits are defined in similar way as for other scenarios above.

Finally, domestic producers in the importing country have to be taken into account. Here yield losses due to contamination are considered and this production-based failure can be conceptualized as a negative shock on supply, inducing a shift or a rotation of the marginal cost curve. If contaminated products enter the importing country, the probability of a given domestic producer being struck by an outbreak if contaminated flowers enter the domestic market is equal to β and the yield loss is equal to θq_d, where q_d is the domestic output and θ is the rate of yield reduction. For an initial output q_d , the probability to encounter the invasive species leading to a production loss is given by[59]

$$G = (1-\sigma) * [(1-\gamma) + \gamma * \psi_L] * \beta$$

With these notations, the domestic producers' expected profit can be determined. We assume that the price that domestic producers receive is equal to p^B . As products are differentiated, this price differs from the price received by the importers. Domestic producers are assumed price takers, because of a relatively small individual size. For domestic producer i with an output $q_{d,i}$, the cost function is

$$c_{d,i} = a_{d,i} * \frac{\varepsilon_{d,i}}{1+\varepsilon_{d,i}} * q_{d,i}^{\frac{1+\varepsilon_{d,i}}{\varepsilon_{d,i}}} + K_{d,i}$$ where, as for foreign producers, a is the variable cost parameter, ε is the price elasticity of supply and K is the sunk cost linked amongst others to the firm's compliance with regulations. The expected profit is equal to

$$\pi_{d,i} = \{G\theta + (1-G)\} * p^B * q_{d,i} - a_{d,i} * \frac{\varepsilon_{d,i}}{1+\varepsilon_{d,i}} * q_{d,i}^{\left(\frac{1+\varepsilon_{d,i}}{\varepsilon_{d,i}}\right)} - K_{d,i}$$

58 . Note that the new as defined here no longer represents the probability of a flower consignment entering the importing country's market, but instead it represents the probability of a Euro worth of flowers entering the importing country's market.

59 . Note that G is independent of ψ_H , the assumption on which therefore only affects foreign producers.

Profit maximization yields individual firm supply functions

$$p_{d,i}^{S}(q)=\frac{1}{G\theta+(1-G)}*a_{d,i}*q^{\frac{1}{\varepsilon_{d,i}}}$$

By assuming N identical producers, the individual supplies can be added up to yield total domestic inverse supply

$$p_{D}^{S}(q)=\frac{1}{[G\theta+(1-G)]*N}*a_{d}*q^{\frac{1}{\varepsilon_{d}}}$$

The overall profits for domestic producers are therefore given by

$$\pi^{D}=N\left[\left([G\theta+(1-G)]*p^{B}\right)^{(1+\varepsilon_{d})}*a_{d}{}^{-\varepsilon}*\frac{1}{1+\varepsilon_{d}}\right]-K_{d}$$

This model abstracts from a number of issues that could be included. Additional damages in the importing country could be taken into account for a more comprehensive assessment. Recall that imports of a contaminated product entail a damage for the importing country, which includes the additional cost of crop protection for producers, the losses linked to the price changes for domestic consumers and the regulator costs for tackling the sanitary problem. Note also that a dynamic approach can be introduced by taking into account time-varying probabilities. Flows over several periods can be taken into account with a discount factor applied to welfare measures.

C3. Data and calibration

This section presents briefly the data and calibration of parameters of the model. As explained above, this application of the cost-benefit framework focuses on the imports of roses by the EU. All the calculation have been performed in an excel spreadsheet that is available upon request.

Quantity of roses imported by the EU from Ecuador, Israel and Kenya in 2007(source: COMEXT)

- Ecuador = 13 194 600 kg (number of stems = 241 292 378)
- Israel = 481 500 kg (number of stems =25 051 798)
- Kenya = 68 012 400 kg (number of stems = 2 553 192 992)

Per unit price received by the foreign producers (p^{A}) and the domestic producers (p^{B})

In the absence of detailed data, the producer price is simply calculated by dividing import value by import volume. The values and volumes of roses imported from Ecuador, Israel and Kenya by EU27 come from the COMEXT database. Domestic producer prices are calculated the same way, using value and volume data on intra-EU imports from the COMEXT database.

Probability of inspection (γ)

In the baseline scenario this probability is assumed to be 0. Under scenarios 1 and 2, this probability is 1. In the last scenario, it is assumed that the EU proceed to reduced checks, using the minimum percentage of consignments to be checked specified by the European Commission and applicable from 01 January 2008.[60] These percentages (for roses) are: 3% for Ecuador, 100% for Israel and 5% for Kenya.

Costs of EU inspection (C)

The costs depend on the number of stems inspected and the length of inspection and therefore in the literature costs are usually decomposed in two parts: a callout fee and a time-varying fee based on the inspection length. The present report uses data provided by Surkov *et al*. (2006, Table 1) and assumes that the inspection length is 30 minutes. The cost associated with one hour inspection is EUR 83.28 (callout fee = EUR 39.94 and 30 minutes fee = EUR 43.34). The number of stems inspected in one hour is equal to 570.

In this analysis, we specify the total inspection costs independantly for each of the three exporting countries, without, however, incorporating them as additional variable costs into the exporters' supply functions. In reality, all importers, even if they have not been inspected, have to pay, implying an additional per-unit cost. We discuss the implications of such additional variable costs further below.

Inspection efficacy (ψ_H and ψ_L)

It is assumed that $\psi_H = 1$, *i.e.* there is no diagnostic error for non-contaminated products. On the other hand, the inspection procedure of contaminated roses is subject to a diagnostic error. The probability of a contaminated product to be detected as a non-contaminated product (ψ_L) is set to 5%.

Probability that the producer offers a non-contaminated product (σ)

As previously mentioned, one way to estimate σ is to observe the proportion of non-contaminated products for a given country. However, data on such proportion are not available for Ecuador, Israel and Kenya. The probability is therefore estimated by using the percentage of accepted consignments in the total number of inspected consignments as a proxy. Data, for the Netherlands, come from Surkov *et al.* (2007). It is assumed that the same numbers apply to the EU27. The approximation seems satisfactory, since the Netherlands are among the most important importers of cut flowers within the EU. For roses, this percentage is 99.66% between 2003 and 2005. As discussed above, this percentage depends on the share of non-contaminated products in the exporters' supplies and is equal to

60. http://ec.europa.eu/food/plant/organisms/imports/recommended_products.pdf; all three of these minimum shares were changed with effect to 1 January 2008, with percentages before that date at 5%, 10% and 1%, respectively. We shall use the older minimum percentages in the context of a sensitivity analysis.

$1\sigma + (1-\sigma)*\psi_L$; using the value for ψ_L above, σ can be calculated as (0.9966-0.05)/(1-0.05) = 0.9964. The probability that the producer offers a contaminated product is equal to 1-σ = 0.0036 (or 0.36%). For the scenario 3 with changed production methods, we assume this probability to be halved.

Supply elasticity (ε)

Flower supply is inelastic in the short term, but precise elasticity estimates are not found in the literature. We assume the supply elasticity equal to 0.2 for both foreign and domestic producers.

Depreciation of flower quality associated with time spent in inspection (δ)

Time spent in inspection reduces the flower quality. Consequently, the price paid to the producer could be reduced. IDEA (2001) emphasizes that a rose which does not achieve Class I may be discounted by as much as 20-30%. In scenario 2, it is assumed that a price reduction is equal to 10%. This is a hypothetical assumption and it does not mean that the time spent in inspection effectively induces depreciation in flower quality.

Marginal cost increase following changes in production

The best way to avoid contamination by harmful organisms is to shift from open field sites to greenhouses, which increases production costs.[61] The present study does not distinguish between fixed and variable costs and only assumes that production costs increase by 10%. With a higher increase, the impact of tighter inspection on the profit of foreign suppliers will be more negative.

Yield reduction (θ) and probability of being struck by an outbreak for domestic producers (β)

As suggested by Surkov *et al.* (2008, Table 4), a yield reduction of 50% is assumed. The probability of a domestic producer being struck by the outbreak if imports are contaminated is difficult to observe and data on this issue are not available. This probability will depend on the contageousness of the invasive species, but also (for a given share of export supplies having entered the domestic market despite of a contamination) on total export supplies. We assume β to be equal to the ratio between the total export supplies of the three countries considered to the total domestic production – in the base situation, β = 0.64[62].

It should be noted that harmful organisms could also affect other crops than roses. However, due to lack of data, we are not able to take into account losses related to infestation of other crops. Table C3 summarises the main parameters used in each scenario.

61. There are other production methods allowing reducing risk of infestation such as use of chemicals, however, production in greenhouses is more environmentally friendly and therefore this method of production is retained in the last scenario.

62. Note this is not the actual probability of a domestic producer facing a yield loss, but conditional on (all) imports being contaminated. The total probabilty is G as discussed above, with a baseline value of some 2.9%. This is a very rough approximation of the actual risk faced by domestic producers. Epedimial studies could provide better estimates.

Table C3. Values of main parameters under the different scenarios

	Baseline scenario	**Scenario 1**	**Scenario 2**	**Scenario 3**
	Current situation	Strengthening of EU inspection	Strengthening of EU inspection and depreciation of flower quality	Reduced checks and changes in the production
Probability that the producer offers a contaminated product (1-σ)	0.36%	0.36%	0.36%	0.18%
Probability of inspection (γ)	0	1	1	Reduced checks: Ecuador = 3% Israel = 100% Kenya = 5%
Inspection efficacy (ψ_H for non-contaminated products and ψ_L for contaminated products)	ψ_H = 100% ψ_L =5%	ψ_H = 100% ψ_L =5%	ψ_H = 100% ψ_L =5%	ψ_H = 100% ψ_L =5%
Price depreciation (δ)	0	0	10%	0
Marginal cost variation	0	0	0	10%

C4. Results

Table C4 provides the results of the different scenarios for 2007.

The first line of results is that inspection costs represent the largest monetary change in all three scenarios. With the exception of Ecuador in scenario 3 (changes in production methods reducing the rate of contamination, followed by a low inspection rate of 3%), the costs of inspection exceed profit changes for both domestic and foreign producers by far in absolute values, and even exceed total profits in scenarios 1 and 2 for Israel and Kenya. Two factors are responsible for this: On the one hand, inspection costs are very large compared to the value of the product. Depending on the country, inspection costs are equivalent to between 49% and 154% of the price received by the exporters, according to the data used for this analysis. On the other hand, the share of import consignments to be inspected (100% in scenarios 1 and 2, 3%-100% in scenario 3) is much higher than their rate of contamination (0.36%). In the base situation, the calculated total damage from contaminated imports to domestic producers of cut roses is some EUR 1.2 million, equivalent to the costs of inspecting just 0.3% of the total imports from the three countries considered in 2007. While there may be other damages than those considered here (*e.g.* if the invasive species is contagious to other flower species, or if consumers lose following higher flower prices; there may also be detrimental consequences of invasive species to the biodiversity in EU member countries if natural habitats are infestated due to contaminated flower imports), this raises the question of commensurability. It should be added, however, that these results strongly rest on assumptions that require further validation, as in particular they depend on the probability of domestic producers being affected by a given share of contaminated consignments passing the border – an epidemiological question that depends on a number of factors not considered in this analysis.

Table C4. Change of export supplies, profits, EU imports and inspection costs in different scenarios

	Absolute changes (kg or EUR)			Relative changes		
	Scenario			Scenario		
	1 Tighter inspections	2 Tighter inspections and quality depreciation	3 Production changes and reduced inspection	1	2	3
Ecuador						
Change in export supply	-8 985	-283 926	-249 266	-0,07%	-2,15%	-1,89%
Change in gross profits	-244 413	-7 332 522	-1 135 081	-0,41%	-12,24%	-1,89%
Change in EU imports	-53 816	-327 823	-249 926	-0,41%	-2,48%	-1,89%
Inspection costs	35 230 081	34 495 476	1 037 643	n.a.	n.a.	n.a.
Israel						
Change in export supply	-328	-10 361	-9 252	-0,07%	-2,15%	-1,92%
Change in gross profits	-8 248	-247 450	-42 231	-0,41%	-12,24%	-2,09%
Change in EU imports	-1 964	-11 963	-10 055	-0,41%	-2,48%	-2,09%
Inspection costs	3 657 707	3 581 438	3 589 868	n.a.	n.a.	n.a.
Kenya						
Change in export supply	-46 311	-1 463 516	-1 285 311	-0,07%	-2,15%	-1,89%
Change in gross profits	-822 942	-24 688 730	-3 829 915	-0,41%	-12,24%	-1,90%
Change in EU imports	-277 396	-1 689 782	-1 290 983	-0,41%	-2,48%	-1,90%
Inspection costs	372 780 925	365 007 832	18 299 263	n.a.	n.a.	n.a.
EU (domestic)						
Change in domestic supply	27 794	27 794	15 359	0,02%	0,02%	0,01%
Change in gross profits	1 145 806	1 145 806	633 027	0,13%	0,13%	0,07%
Total inspection costs	411 668 713	403 084 746	22 926 773	n.a.	n.a.	n.a.

Pro-memory: Gross profits ignore sunk costs K that might change across scenarios. Potential additional sanitary damages for the importing country not considered.

A second result can be seen in the finding that losses in gross profits for foreign producers depend much more on the value losses of the flower due to the inspection duration than on the risk of a consignment not passing the inspection. This is highlighted by the differences between scenarios 1 (full inspection) and 2 (full inspection and 10% value depreciation associated with time spent in inspection). The depreciation of flower quality and hence the reduction of achievable prices creates profit losses that rise more than proportionally with the rate of price reduction as gross despite the fact that producers will incorporate the lower average price in their production decision: export supplies and hence imports are reduced. While this obviously strongly depends on the degree of value depreciation of inspected flowers (assumed at 10%), a simple sensitivity analysis shows that even a 1% rate of reduction in the flower price would cause losses in foreign gross profits three times higher than those induced by consignment not passing the inspection.

Thirdly, the results suggest that the losses faced by foreign producers tend to be large compared to the benefits for domestic producers of roses in the EU, and in fact significantly exceed them in the two latter scenarios. As discussed above in the context of relative inspection costs, this result also strongly depends on the likelihood of domestic producers to be damaged by contaminated imports.

Fourthly, total flower supplies (by domestic producers and imports from the three countries considered in this analysis) are found to decline by between 300 and 2 000 tonnes in the three scenarios, equivalent to some 0.15% to 1% of baseline quantities. While these changes are not completely negligible, the results suggests that consumers are unlikely to see major price (and hence welfare) changes, nor should domestic of foreign producers face major changes in achievable product prices. In so far, ignoring consumers in this analysis and holding market prices fixed does not seem to be a major problem for the results, even though this in turn would depend on the responsiveness of flower consumers to price changes. This result, however, also ignores the possible effects of changed production methods and/or inspections on the fixed cost element K. While not relevant for the optimal production decisions of the individual firm in the short term, such changes would affect entry and exit decisions within the market and hence could have indirect implications for foreign supplies.

These general results are fairly robust with respect to the choice of a number of parameters, even though different parameter values generally alter the absolute level of these results. The assumption of supply elasticities equal to 0.2 for both foreign and domestic producers is, as described above, not based on any empirical evidence. A higher elasticity would result in only slightly different profit changes for scenarios 1 and 2, whereas losses for foreign producers would be almost twice as high given that the costs to be increased by 10% represent a much higher share of the producers' revenue. For the same reason, relative profit changes are significantly higher for all scenarios with the higher supply elasticity, too, as are changes in export and domestic supplies.

Alternative probabilities of false-positive tests in the inspection of flowers have only modest implications for the results, without changing general findings. A doubling of this probability to 10% obviously results in slightly lower losses for foreign producers (as a higher share of their produce would pass the inspection) but slightly lower gains for domestic ones (as the likelihood of a production damage increases). Given the magnitude of the losses due to value depreciation at the border, however, these differences become almost negligible for foreign producers in scenario two, and due to the low shares of inspected consignments from Ecuador and Kenya are noticable only in the case of Israel in scenario 3.

A higher sensitivity of the results is found for the rate of contamination in exporters' supplies. While the rate used in this analysis is based on some empirical analysis, a contamination share of 0.36% in the export consignments bears some uncertainty, too. Higher based rates significantly increase both the profit losses to foreign producers due to inspection (and hence lower imports) and the avoided damage to domestc producers (or any other damage in the importing country not considered here, as enumerated above), and differences compared to the results above can be significant: a contamination share of 1% would increase foreign profit losses and domestic profit gains by some 180% in scenario 1. It would take, however, an unrealistically high base contamination share of almost 13% to make domestic profit changes balance the total inspection costs in scenario 3, assuming a halving of contamination rates due to greenhouse production. Rates higher than 85% would be a condition for domestic profit changes balancing total inspection rates in the first two scenarios.

To complete the results, the issue of financing inspection costs should be considered. The following three means of financing are commonly used by public agencies or inspections administrations: i) a fixed user fee, ii) a per unit user fee or iii) a public financing program via taxes.

In the case analysed here, total costs of inspection are proportional to the export supplies offered at the EU border. A per unit fee charged to the exporters would increase marginal costs and would hence be passed on to consumers via the price. Depending on the consumers' response to the prices of foreign relative to domestic prices, however, this would likely reduce the competitiveness of foreign producers on the EU market. This also holds if the total costs of inspections are shared across all consignments arriving at the EU border, irrespective of whether they actually are inspected or not, as it is foreseen by existing EU regulations. Model results for this case[63] suggest that the additional inspections in scenarios 1 and 2 would caus substantial additional profit losses for producers in Ecuador, while inspection costs would be prohibitive for exports from both Israel and Kenya. For Israel, even changes in the production process (greenhouses) would not be a solution given the maintained 100% inspection rate in scenario 3, whereas profit losses in scenario 3 would be around 4% and 11% for Ecuador and Kenya – higher than without consideration of inspection costs, but still moderate.

When the cost of inspection is sunk (through additional investments) and does not depend on the scale of the inspection activity, corresponding fixed user fees imposed on firms are not passed onto consumers via the price, and hence only foreign producers will incur them and not domestic consumers. There is a risk that this fee can exclude foreign competitors. If compliance with inspections and controls implies large investments that are sunk once undertaken, economies of scale become an important factor for the industry. Sunk costs related to inspections programs may become an entry barrier for certain foreign producers. Not all firms will meet the new inspection standards and the structure of the industry and trade can profoundly change. This is leading to concerns regarding market participation, particularly, in low-income countries. Often this unequal ability to meet standards causes dualism in the industry affected by the new regulatory environment.

Finally, it is important to briefly discuss the question of the functional form used to represent production decisions. Other than proposed in OECD (2008), this analysis employes isoelastic supply functions. Indeed, the choice of linear supply functions (or, equivalently, quadratic cost functions) would not have had major implications in terms of absolute changes in quantities or profits for the first two scenarios, *i.e.* as long as the supply curves remain unchanged. Relative profit changes are very different as there are major differences in total production costs assumed behind the two functional forms. The choice of the functional form becomes crucial, however, for scenario 3 where we assume changes in the production methods (greenhouse instead of free-range production) and associated marginal costs. As due to the low price elasticity of supply (well below 1) the intercept with the price axis for the linear functions becomes strongly negative, results coming from a linear model become strongly distorted both in terms of

63. As we do not consider the importer as a separate agent, we incorporate inspection costs for imports from one country into the total export supply of that country.

production changes and in terms of profit losses This once more highlights the importance of chosing an appropriate functional form for the model, and issue that is the more relevant the more the price elasticity of supply differs from 1.[64]

C5. Conclusion

This report analyses the costs and benefits of tighter border inspection to prevent imports of plant diseases. This is a "producer externality" issue (OECD 2008), where trade acts as a conduit of negative effects for domestic producers through yield losses and reduced commercial value of their product. The EU's "Community Plant Health Regime" aims at preventing the introduction into and the spread within the Community of organisms harmful to plants or plant products. Potential losses and gains, associated with this European legislation, are estimated for those countries that, concerned by the new regulation, raised (Ecuador and Israel) or supported (Kenya) the issue in the WTO SPS Committee. The focus is on roses imported by the EU from these three countries. In addition to the costs and benefits for the exporting countries of cut flowers, the assessment also includes inspection costs for the EU.

The analysis demonstrates the strong relationship between the impacts on producers and the probability of infection as well as to the probability of detection at the border. The results indicate that tighter inspection leads to losses for foreign suppliers, especially if inspection coincides with depreciated quality due to time spent during the inspection. Improved production methods in exchange for reduced inspection tightness also lead to diminished profits for foreign suppliers, because of higher production cost they must incur. In all cases, the increase in inspection costs outweighs the estimated gain to domestic producers from being less prone to the plant disease. Finally, the analysis suggests that taking all costs and benefits together, the estimated net benefits of tighter inspection are negative.

These general results are fairly robust with respect to the values used for most parameters. The level of contamination in foreign supplies, however, is a major determinant of the results, and the magnitude of both profit losses to foreign producers and gains in the importing countries strongly depend on this. Cost efficient improvements of production methods in countries exporting to the EU that can result in lower contamination rates therefore can be seen a major step to avoid costs on both sides of the border.

64. In the case of a unit price elasticity of supply, the linear and isoelastic models become perfectly equivalent.

Appendix C1.

Descriptive statistics

Table C1. Imports of cut flowers, by OECD country in 2006 (million USD)

Country	Imports	Country	Imports
Germany	1 089.5	Ireland	49.6
United Kingdom	1 004.9	Norway	46.4
United States	980.2	Czech Republic	42.1
Netherlands	590.8	Greece	31.8
France	520.8	Finland	23.4
Japan	241.2	Portugal	19.8
Italy	220.8	Hungary	19.6
Switzerland	165.9	Slovakia	15.5
Belgium	142.5	Luxembourg	12.1
Austria	107.7	Australia	8.6
Canada	104.0	Mexico	3.2
Spain	99.1	Republic of Korea	2.4
Denmark	97.4	New Zealand	0.8
Sweden	89.8	Iceland	0.7
Poland	57.8	Turkey	0.4

Source: UN COMTRADE

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