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Technical Barriers Affecting Agricultural Exports from China: The Case of Fresh Apples

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Abstract

It is widely recognized that technical barriers create numerous obstacles to world agricultural trade. Technical barriers are broadly defined as regulations to protect plant, animal and human health, as well as other measures and standards related to product quality. Such barriers exist in most industries, but are particularly important in the trade of primary and processed agricultural products, where they have become critical determinants of trade opportunities.

The Uruguay Round of the General Agreement on Tariffs and Trade (GATT 1994) has established specific rights and obligations of signatory nations of the World Trade Organization (WTO) with respect to technical trade barriers. These agreements stipulate that technical barriers to trade (TBT) achieve legitimate objectives in a manner that is least trade distorting. Specifically, under the WTO agreements, TBT measures should not constitute disguised restrictions on international markets, nor be applied in an arbitrary or discriminatory manner. Countries are to adopt only those sanitary and phytosanitary (SPS) measures (related to protection of plant, animal, and public health) that are justified by objective scientific evidence. One approach to achieving the WTO objectives for SPS measures is to apply a “systems approach” of compliance steps that exports must adhere to in order to reduce pest risks associated with trade.

This report addresses technical barriers that limit the agricultural trade of China in the case of phytosanitary barriers to fresh apple exports. Apple production in China has increased substantially in recent years and now accounts for nearly half of the total global output. Correspondingly, in many of its discussions with trade partners about agricultural technical barriers, China has highlighted apples and pears as products for which it has sought market access. China’s apple exports have skyrocketed as markets have been opened. In the 2004/05, China exported 850,000 metric tons of fresh apples, a nearly five-time increase in the export volume over five years. A large proportion of the increase in Chinese apple exports have gone to the Pacific Rim markets, such as Hong Kong and the Philippines.

Eliminating unnecessary technical barriers to trade, or modifying barriers to achieve legitimate regulatory goals in the least trade-distorting manner, is ultimately beneficial when there are economic gains from trade. When existing barriers preclude trade, the potential gains have to be assessed in counter-factual empirical models. Orden and Roberts (2007) argue, on conceptual grounds and from practical experience, that science (evidence of limited risk), opportunity (clear incentives for trade arising from price differentials that would lead to exports), traceability (to ensure sources of any pest infestations can be traced back to their origin), persistence (on the part of potential exporters) and joint political will (to reach an accord by the negotiating governments) are all necessary conditions for progress in achieving opening of markets with respect to SPS barriers.

Because each technical barrier rests on specific criteria and the trade patterns affected are unique, the analysis of specific cases is required to assess the impacts of any change in import regulations. In this report, an integrate analysis is utilized to evaluate the economic efficiency and welfare effects of the removal of the phytosanitary restrictions on imports of Chinese fresh apples to the markets of North America. The importation of Chinese fresh apples from approved

orchards and packers in selected provinces has been authorized by Canada since December 2002 but importation of fresh apples remains banned by the United States. The Chinese apples imported by Canada are mainly sold to its Asian communities as fresh fruit. Due to the high quality of the apples imported from China, they are sold at relatively high prices as a somewhat specialty product.

The change in regulation by Canada may signal an eventual larger opening of the North American market to Chinese apples. In order to examine the impacts of allowing greater access of Chinese fresh apples into North America a static partial equilibrium model in which apples from different sources (countries/regions) are treated as imperfect substitutes in consumption and production is developed. The regions of the model comprise three net exporters (the U.S., China, and a conglomerate region of Southern Hemisphere exporters (SHE) represented by Argentina, Chile and New Zealand). Net importing regions are non-U.S. North America (NA composed of Canada and Mexico), the ASEAN region, the EU-15, and an aggregate rest of world (ROW). The scope of the model is chosen to allow an adequate representation of substitution possibilities within global markets while also facilitating a particular emphasis on the trade and pest-risk effects resulting from a change in the U.S. regulations.

In the simulation analysis, it is assumed that Chinese exports to the U.S. would achieve a market share similar to the importation into Canada of fresh apples from China in a benchmark period (average of 2003-2004) subsequent to opening of the Canadian market. We first assume there is no risk associated with trade. Apples from China obtain a share of about 3 percent of the total U.S. apple consumption and sell at a price above the U.S. market average, similar to the situation for Canada. This is not a dramatic change in domestic or global market circumstances but there are consumer benefits from increased variety, so there is a small net U.S. welfare gain from allowing imports. Likewise there is a small net gain for China as its apple producers benefit.

We next evaluate the outcomes when risk is assumed. Three estimates of fruit losses and control costs related to the pest infestations that could result from importation of apples are incorporated into the model based on a literature review of their plausible ranges. Because the probability of pest outbreaks due to the importation of fresh apples from China in the U.S. is not known, we can not simulate the welfare impacts of trade associated with specific estimates of the risk from trade. As an alternative analysis, the risk probability levels are assessed that result in the expected change in U.S. welfare from granting market access to Chinese fresh apples being brought approximately equal to zero. Higher levels of risk from trade would result in expected welfare losses. As the assumed fruit losses and pest control costs rise, it takes a lower level of risk being achieved to be consistent with a gain in U.S. welfare. In the case of our assumed "low costs" from pest infestations the risk probability that leaves welfare unchanged corresponds to an expected frequency of a trade-related pest outbreak of approximately 0.2 per year, or one every five years. For the cases of "average cost" and "high cost," the expected frequency of an outbreak that leaves U.S. welfare unchanged drops to 0.06 and 0.02 per year, respectively. These estimates illustrate the levels of risk mitigation that a systems approach would have to achieve in order for importation of fresh apples from China by the United States to result in a net U.S. welfare gain.

The structure of the report is as follows. Section 2 provides an overview of world apple production, consumption and trade with a focus on the growth of China's production and exports and on the North American market. Section 3 discusses the pest risk assessments, the application of systems approaches of compliance measures designed to reduce risks associated with exported products, and the history of rule making by Canada and other countries with respect to importation of Chinese apples and pears. From this analysis, a hypothetical systems approach is developed for fresh apple imports by the United States. Section 4 provides insights about the Chinese apple exporting industry obtained from field research interviews conducted in Beijing and Shandong Province during July 2006 and July 2007. The economic model built on the basis of this background is presented in Section 5. The model benchmark data is described, a technical description of the model is provided, and the simulation results are presented and discussed.

1. Introduction

It is widely recognized that technical barriers create numerous obstacles to world agricultural trade. Technical barriers are broadly defined as regulations to protect plant, animal and human health, as well as other measures and standards related to product quality. Such barriers exist in most industries, but are particularly important in the trade of primary and processed agricultural products, where they have become critical determinants of trade opportunities.

The Uruguay Round of the General Agreement on Tariffs and Trade (GATT 1994) has established specific rights and obligations of signatory nations of the World Trade Organization (WTO) with respect to technical trade barriers. These agreements stipulate that technical barriers to trade (TBT) achieve legitimate objectives in a manner that is least trade distorting. Specifically, under the WTO agreements, TBT measures should not constitute disguised restrictions on international markets, nor be applied in an arbitrary or discriminatory manner. Countries are to adopt only those sanitary and phytosanitary (SPS) measures (related to protection of plant, animal, and public health) that are justified by objective scientific evidence.[1]

The new WTO rules have heightened the profile of technical barriers to trade and increased the international dialogue over their application. Whether these barriers are effectively disciplined is important for four key reasons. First, sovereign countries have to be able to impose regulations that address health, safety and quality goals, but international guidelines serve to constrain narrowly-focused national regulatory decisions. Second, the argument has been advanced that the SPS and TBT agreements impose undue administrative costs on developing countries. In exchange, poor countries ought to be able to benefit from the agreements by gaining market access that enhances their ability to participate in world trade. Third, world agricultural trade is growing fastest in high-value products, such as meats and fruits and vegetables, for which technical standards are most important. Fourth, the standards for agricultural and food products traded in international markets are evolving rapidly under various forces, ranging from

[1] SPS measures are addressed in the GATT 1994 Agreement on the Application of Sanitary and Phytosanitary Measures. TBT measures are addressed in the GATT 1994 Agreement on Technical Barriers to Trade. Other agreements, including the TRIPS agreement, other articles of the GATT, and some multilateral environmental agreements, also play a role in defining the latitude and limits to technical regulations within the agricultural and food sectors. See WTO (1999) and Josling, Roberts and Orden (2004).

newly emerging threats, to scientific advances affecting production and processing, to changing consumer incomes and preferences.[2] To address these many issues, both exporters and importers need rules, as in the WTO, for determining the legitimate scope and instrumentation of regulations.

This report addresses one set of technical barriers, particularly SPS barriers to Chinese fresh apple exports, that limit the agricultural trade of China. As agricultural reforms have occurred in China, agricultural production and trade have grown strongly. China alone accounts for one-fifth of world agricultural production. It became the 143rd member of the WTO on December 11, 2001, and the value of its agricultural exports and imports reached \$17.3 billion and \$ 32.9 billion, respectively, in 2004. Adjustments in China's trade policy, including tariff reduction policies, have significantly changed China's agricultural export and import structure. Agricultural trade has moved in a direction that is more consistent with China's comparative advantage. For example, the proportion of grain exports fell to 20 percent of total agricultural exports in the 1990s, from more than 40 percent in the 1980s (Huang and Rozelle, 2002). Horticultural, animal, and aquatic products accounted for more than 80 percent of agricultural exports in the late 1990s. By re-grouping trade data according to factor intensity in production, Huang and Rozelle conclude that China's net exports of land-intensive bulk commodities, such as grains, oilseeds, and sugar crops, have fallen, while exports of high value and more labor-intensive commodities have risen.

In terms of the effects of technical barriers on the export opportunities of developing countries two themes have arisen since the WTO agreements came into effect. The first theme is that high standards, especially unjustifiably high standards, discriminate against developing countries, and particularly against poor farmers in these countries for two reasons: because they are difficult for exporters to meet and because the developing countries lack the resources to participate actively in the standard setting process through either bilateral or multilateral mechanisms. The second theme is that the increasingly differentiated markets for agricultural and food products in developed and middle-income countries open opportunities for developing countries. Both themes have some merit. Specific cases consistent with each have been identified (e.g. ACIAR (2005), Mehta and George (2005), World Bank (2005)) and net assessment of the

[2] Standards establish product specifications for common and repeated use, and may be either mandatory or voluntary.

effects is ongoing. The first theme puts an onus of responsibility on developed countries and their regulatory decisions. The latter theme highlights the important role of multinational supply chains and private sector investment, placing more emphasis on investment climate determinants and other public sector decisions of the developing countries.

Eliminating unnecessary technical barriers to trade, or modifying barriers to achieve legitimate regulatory goals in the least trade-distorting manner, is ultimately beneficial when there are economic gains from trade. When existing barriers preclude trade, the potential gains have to be assessed in counter-factual empirical models. Likewise, when a proposed barrier might limit existing trade opportunities, the effects of its adoption can be estimated. Neither the SPS nor TBT agreement of the WTO requires that regulations adopted by countries take into account their economic benefits and costs—in that sense the legal requirements do not provide a template for optimal regulation. But benefit-cost assessments inform policy decision makers, and are often required as part of regulatory decision processes. Orden and Roberts (2007) argue both on conceptual grounds and from practical experience that science (evidence of limited risk), opportunity (clear incentives for trade arising from price differentials that would lead to exports), traceability (to ensure sources of any pest infestations can be traced back to their origin), persistence (on the part of potential exporters) and joint political will (to reach an accord by the negotiating governments) are all necessary conditions for progress in achieving opening of markets with respect to SPS barriers.

As its agricultural trade has opened up, China has been one of the developing countries that has confronted the challenge of opening markets and meeting the SPS standards set by its trade partners. With the rapid expansion of China's exports health and safety problems with some of its products have made headline news during the past two years. Concern has also been expressed that technical regulations are being used to discriminate against some of its exports. Neither the scope of these problems nor their economic consequences have been fully identified. Some reports suggest a very high cost of technical barriers in terms of lost export sales. For example, one Ministry of Commerce report concludes that almost 90 percent of Chinese agricultural exports faced overseas technical barriers that resulted in US$ 9 billion of lost export sales (Zhu, 2003). In contrast, China has pursued only a few cases of technical barrier disputes through the informal and formal dispute settlement processes established by the WTO.[3] This discrepancy suggests the need for further analysis to identify the opportunities that exist for expanding China's agricultural trade through modification of regulations imposed by importers that are questionable under international disciplines, or by making additional private and public investments to meet legitimate requirements that are imposed.

Because each technical barrier rests on specific criteria and the trade patterns affected are unique, the analysis of specific cases is required to assess their impacts. In this report, an integrate analysis is utilized to evaluate the economic efficiency and welfare effects of the removal of the phytosanitary restrictions on the import of Chinese fresh apples to the markets of North America. In many of its discussions with trade partners about agricultural technical barriers, China has highlighted apples and pears as products for which it seeks market access. The importation of Chinese fresh apples from approved orchards and packers in selected provinces has been authorized by Canada since December 2002 but importation of fresh apples remains banned by the United States (U.S.). The Chinese apples imported by Canada are mainly sold to its Asian communities as fresh fruit. Due to the high quality of the apples imported from China, they are sold at relatively high prices. For example, the price of Chinese Fuji apples was CA$35 per box in 2003 compared to U.S. and Canadian Fuji's which were sold for CA$18 - CA$22 per box (Carter, 2003).

The change in regulation by Canada may signal an eventual larger opening of the North American market to Chinese apples.[4] The potential importation of larger quantities of fresh apples from China has created concerns for the domestic apple growers in both Canada and the U.S. Apple production in China has increased substantially in recent years and now accounts for nearly half of the total global output. Correspondingly, China's apple exports have skyrocketed. In the marketing year 2004/05, China exported 850,000 metric tons of fresh apples, a nearly five-time increase in the export volume over five years. A large proportion of the increase in Chinese apple exports have gone to the Pacific Rim markets, such as Hong Kong and the Philippines, displacing apple exports from the U.S. and Canada.

[3] Through October 2003, there were seven informal challenges raised by China to SPS regulations affecting its exports: two concerning the EU (over maximum residue limits and regulations on animal products), two concerning Japan (maximum residue limits and use of emergency measures), one concerning the Philippines (fruit regulations) and one concerning the United States (restrictions on potted plants). See WTO, 2004.

[4] In October 2005, Mexico also signed an agreement with China allowing the imports of Chinese fresh apples.

One relevant issue is that China has not convinced the Canadian and U.S. apple growers that it can effectively implement phytosanitary controls on apple exports. A nine-month suspension on the importation of fresh apples from Shaanxi province by Canada in 2004 provides an example. The suspension was imposed due to repeated interception of quarantine pests. A similar problem arose on Chinese Ya pear imported into the U.S. in late 2003. Over three million pounds of Chinese Ya pears were removed from supermarket shelves because diseased Chinese pears infested with exotic *Alternaria* fungus were found (Wenatchee World, 2004). The Canadian and U.S. apple industries are concerned that entry of fresh apple imports from China may lead to the introduction of new insects and diseases that will infest apple orchards and cause debilitating losses to the apple growers in both countries. Such a concern, if valid, is a legitimate reason to maintain restrictive phytosanitary measures.

China's apple industry has made tremendous progress since 1990s but it still largely depends on relatively primitive production technologies. The availability of low-wage labor in rural China makes it possible to produce fresh apples at low prices. But transportation, storage and adequate pest and disease control are challenges that China's apple industry faces. The operating system in Chinese orchards explains the pest and disease control problem of Chinese fresh apples. Chinese apple orchards are often no larger than an acre and they neither have a scientific system that provides phytosanitary and human health safeguard nor a universal inspection service. Chinese shippers often draw supplies from many of these small apple growers making it hard to guarantee the absence of pests and diseases from exported apples. In a few other cases, larger orchards are managed directly by exporting firms, with higher standards to meet export market requirements.

In order to ensure phytosanitary compliance of apples exported to Canada, a license needs to be issued to each exporter by the Administration of the People's Republic of China for Quality Supervision and Inspection and Quarantine (AQSIQ). Only after the exporter has convinced the officers from AQSIQ that it has the ability to meet the phytosanitary regulations imposed by Canadian Food Inspection Agency (CFIA) can it get the license. Higher costs are expected for producing apples exported to Canada because additional costs will be incurred to comply with the CFIA's regulations. Therefore, the proportion of Chinese fresh apples that can consistently meet CFIA's phytosanitary requirements and the compliance costs incurred during the production of these high-quality apples should be considered in evaluating potential effects of imports from China on the North American apple markets.

Since countries may use strict phytosanitary requirements as a means of protecting their domestic producers from competitive foreign products, questions arise in the case of apples as to whether Canadian and U.S. phytosanitary regulations regarding Chinese fresh imports are entirely based on science; what the economic consequence would be from increased market access; whether the North American apple industry is overly cautious about the imports of fresh apples from China to disguise an intention of protecting their domestic producers from market competition; whether the production losses in the event of pest infestations will offset the consumers gains in the North American market from less restricted imports of Chinese fresh apples; and how potential new trade opportunities would affect the global apple trade flows and the world market.

In order to address these questions, a static partial equilibrium model in which apples from different sources (countries/regions) are treated as imperfect substitutes in consumption and production is developed in this report to examine the impacts of allowing greater access of Chinese fresh apples into North America. The regions of the model comprise three net exporters (the U.S., China, and a conglomerate region of Southern Hemisphere exporters (SHE) represented by Argentina, Chile and New Zealand). Net importing regions are non-U.S. North America (NA composed of Canada and Mexico), the ASEAN region, the EU-15, and an aggregate rest of world (ROW).[5] The scope of the model is chosen to allow an adequate representation of substitution possibilities within global markets while also facilitating a particular emphasis on the trade and pest-risk effects resulting from a change in the U.S. regulations. We concentrate on production, consumption and trade of fresh apples, with adjustments to the world production data to account for use of apples for juice and other processed products. A nested Constant Elasticity of Substitution (CES) demand system is employed to represent consumer demand for fresh apples from different regions and a Constant Elasticity of Transformation (CET) production possibility frontier is utilized to allow the supply of fresh apples from each country to shift between demand regions with changes in the relative

[5] The ASEAN members are Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

prices producers receive. There is a positive linear supply relationship assumed between the overall apple price index and aggregate apple production.

In the simulation analysis, it is assumed that Chinese exports to the U.S. would achieve a market share similar to the importation into Canada of fresh apples from China in a benchmark period (average of 2003-2004) subsequent to opening of the Canadian market. We first assume there is no risk associated with trade. Apples from China obtain a share of about 3 percent of the total U.S. apple consumption and sell at a price above the U.S. market average as a somewhat specialty product, similar to the situation for Canada. This is not a dramatic change in domestic or global market circumstances. But there are consumer benefits from increased variety, so there is a small net U.S. welfare gain from allowing imports. Likewise there is a small net gain for China as its apple producers benefit.

We next evaluate the outcomes when risk is assumed. Three estimates of fruit losses and control costs related to the pest infestations that could result from importation of apples are incorporated into the model based on a literature review of their plausible ranges. However, the probability of pest outbreaks due to the importation of fresh apples from China in the U.S. is not known, since trade has not taken place, nor did we find any quantitative estimates of this trade-related risk. Thus, we can not simulate the welfare impacts of trade associated with specific estimates of the risk from trade.

As an alternative analysis, the risk probability levels are assessed that result in the expected change in U.S. welfare from granting market access to Chinese fresh apples being brought approximately equal to zero. Higher levels of risk from trade would result in expected welfare losses. Given the limited volume of trade resulting from a U.S. market share for Chinese apples similar to their share in Canada, we assess this upper-bound of risk per kilogram of imports that a systems approach would have to reduce risk below in order for importation of fresh apples from China to result in expected U.S. welfare gains in our model. As the assumed fruit losses and pest control costs rise, it takes a lower level of risk being achieved to be consistent with a gain in U.S. welfare. In the case of our assumed "low costs" from pest infestations the risk probability that leaves welfare unchanged corresponds to an expected frequency of a trade-related pest outbreak of approximately 0.2 per year, or one every five years. For the cases of "average cost" and "high cost," the expected frequency of an outbreak that leaves U.S. welfare unchanged drops to 0.06 and 0.02 per year, respectively. Again, these estimates illustrate the levels of risk mitigation that a systems approach would have to achieve in order for importation of fresh apples from China by the United States to result in a net U.S. welfare gain.

The structure of the report is as follows. Section 2 provides an overview of world apple production, consumption and trade with a focus on the growth of China's production and exports and on the North American market. Section 3 discusses the pest risk assessments, the application of systems approaches of compliance measures designed to reduce risks associated with exported products, and the history of rule making by Canada and other countries with respect to importation of Chinese apples and pears. From this analysis, a hypothetical systems approach is developed for fresh apple imports by the United States. Section 4 provides insights about the Chinese apple exporting industry obtained from field research interviews conducted in Beijing and Shandong Province during July 2006 and July 2007. The economic model built on the basis of this background is presented in Section 5. The model benchmark data is described, a technical description of the model is provided, and the simulation results are presented and discussed.

2. Global Apple Production, Consumption and Trade[6]

2.1 Global Apple Production

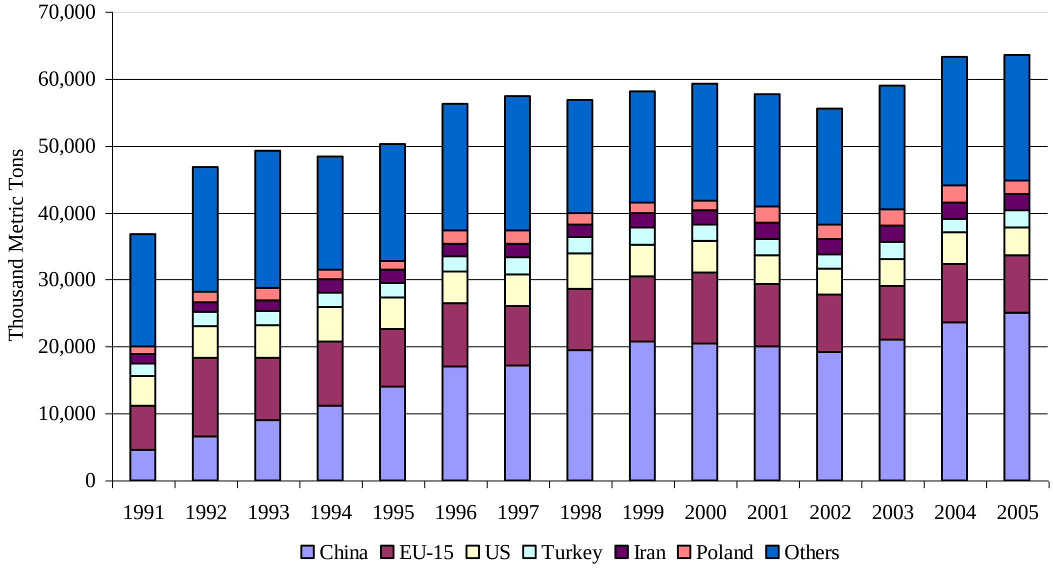
Apples are one of the most popular fruits in the world and are produced in more than 90 countries. This delicious and hardy fruit grows in moderate climate regions from 30 to 60 north latitude and 25 to 45 in the southern hemisphere. Over 3000 apple varieties are available ranging in size from a little larger than a cherry to as large as a grapefruit. Golden and Red Delicious, Royal Gala, and Granny Smith are the most popular varieties in North America and Europe whereas Fuji is the favorite of Asian consumers.[7] Apples can be kept in cold or controlled atmosphere storage, which with the best technology, allows them to be kept fresh without a decline in quality for nearly a year.

In 2005, the world apple supply was over 63 million metric tons, a 75 percent increase compared to the volume produced in 1991 (FAOSTAT, 2006; see Figure 2.1 and Appendix I). Most of the growth is attributed to the improved world average yield, which has been increasing steadily and reached 12,097 kilogram/hectare in 2005, a 63 percent rise compared to that of 15 years ago. (FAOSTAT, 2006) World apple acreage expanded from 1991 to 1995 and then areas declined until 2003. A small expansion in apple acreage occurred in the subsequent two years (FAOSTAT, 2006).

World apple production is concentrated in several major apple-producing countries. In 2005, about 70 percent of the total world apple supply was provided by the ten leading apple producers. According to the FAO production statistics, the top ten ranking in terms of quantity of apples produced has changed slightly since 2000 (Table 2.1). However, China continuously led the world in apple production followed at a much lower level of total output by the United States.

[6] This section is drawn primarily from chapter 2 in Xue, 2007.
[7] Other popular varieties include Cortland, Northern Spy, Mutsu, Ashmead's Kernel, Rob Roy, Spartan, Graven stein, Pitmaston Pineapple, Ambrosia, Newton, Red Astrachan, Rambour, Rose of Caldaro, Stark Crimson, Cellini, Gray Dennet, Stayman, Roman Beauty, Baldwin, Wealthy, Annurca, Yellow Beauty, York Imperial, Jonathan, McIntosh, Grimes Golden, Yellow Newton and Red Richard.

Figure 2.1. World Apple Production, 1991-2005



Source: FAOSTAT, 2006

Table 2.1. World Leading Apple Producers, 2000 and 2005

	Year 2000			Year 2005	
Ranking	**Country**	**Production (000 MT)**	**Ranking**	**Country**	**Production (000 MT)**
		Leading producers			
1	China	20,437	1	China	25,007
2	USA	4,682	2	USA	4,254
3	Germany	3,137	3	Turkey	2,550
4	Turkey	2,400	4	Iran	2,400
5	Italy	2,232	5	Italy	2,195
6	France	2,157	6	France	2,123
7	Iran	2,142	7	Poland	2,050
8	Russia	1,832	8	Russia	2,050
9	Poland	1,450	9	Germany	1,600
10	Brazil	1,153	10	India	1,470
Top-10 Subtotal		41,622			43,699
World Total		**59,039**			**62,463**

Source: FAOSTAT database

In order to better understand the global apple industry, descriptions of several of the leading apple producers are provide below.

China

China's apple production rose sharply in the 1990s, from 4.3 million metric tons in 1990 to 20.8 million metric tons in 1999.[8] Then it became more stable between 20-25 million tons during 2000 to 2005 (FAOSTAT, 2005). Earlier acreage expansion and favorable weather, combined with the continuing maturation of planted trees, are major reasons for the increase in China's apple crop. But the relatively primitive technology used in China's apple industry still resulted in relatively low apple crop yield. In 2005, the average apple yield in China reached 11,363 kg/hectare, 1.4 times the yield in 1995. Even with the significant increase, the average yield in China remains below the world average. Still, total Chinese apple supply in 2005 accounted for 40 percent of the global production and the output is over five times that of the U.S. (FAOSTAT, 2005).

Currently there are 25 provinces growing apples in China. Most of these provinces are in four apple production regions. Bo Hai Wan is the traditional production area which accounts for almost half of the total area of apple orchards in China. Within this region, Liaoning, Shandong, Hebei, Beijing and Tianjin are the major apple producing provinces. The Northwest and Southwest Highland area is the second largest apple producing region accounting for one-third of the overall apple supply in China. Shanxi, Gansu, Shaanxi, Ningxia and Qingzang provinces belong to this production region. The Yellow River and Qing Mountain Range Area is a relatively new apple production region founded in 1958, which includes eastern Henan province, southwestern Shandong province, northern Jiangsu province and northern Anhui province. This region provides about 16 percent of the total Chinese apple output. Finally the Southwest cold and highland area is fairly small in terms of apple production. It only accounts for 4 percent of the total apple-producing area in China and supplies 1 percent of the fresh apples (Gao, 2006).

Since 1978, the apple industry in China has modernized by introducing and adopting new and improved apple varieties. Currently Fuji apple[9] is the most widely grown apple variety, to which nearly half of the total Chinese apple planting areas is devoted. The old variety Rall has a share of 14 percent of the total apple planting area and other improved varieties like Delicious,[10]

[8] The apple is the largest fruit variety in China, accounting for about 30 percent of the Chinese overall fruit production.
[9] Fushi is the name for Fuji apples in China.
[10] Yuanshuai is the name for Delicious apples in China.

Golden Deli and Gala, account for 10 percent, 6 percent and 3 percent of the overall planting area, respectively (Gao, 2006).

After the expansion in the early 1990s, apple acreage in China declined from 1996 to 2002, though apple production continued to increase. Apple acreage in China has been projected to continue decreasing at a slow rate as growers shift into more profitable horticultural crops such as cherries, strawberries and various vegetables (Skorburg, 2001). But the production growth potential of Chinese apples is still high. Seventy percent of China's apple trees are bearing now and the proportion is still increasing. Most of the trees are young and will produce for up to 30 years. Apple yields are improving in China but current Chinese apple yields are only 60 percent of that of the high productivity countries, such as the U.S., on a per hectare basis. This implies the potential for increased Chinese apple yield. With China's apple industry implementing more advanced technology, production of Chinese fresh apples should continue to rise even on less acreage.

All high-cost apple producing and exporting countries are facing intense competition from China and a few other low-cost producers, as there are substantial differences in labor costs between the low-cost and high-cost producing countries. This difference may translate into a significant price difference. Apple production is labor-intensive because thinning, pruning, tree training and harvesting, all are performed by hand year-round. China's labor cost has been estimated to be $374 per acre, only 18 percent of the labor cost in the U.S., which is estimated at $2,052 per acre, as shown in Table 2.2 (Foster, 2005). Low labor costs also occur in Brazil and Poland. The latter countries are also significant apple producers but not on the scale of China. The low labor cost contributes to the low Chinese apple production costs. But the higher-cost producers remain competitive because of 1) higher per acre productivity, 2) consumer preferences for high-quality fresh apples, and 3) trade barriers.

Table 2.2. Production Costs for Major Apple Producing-countries

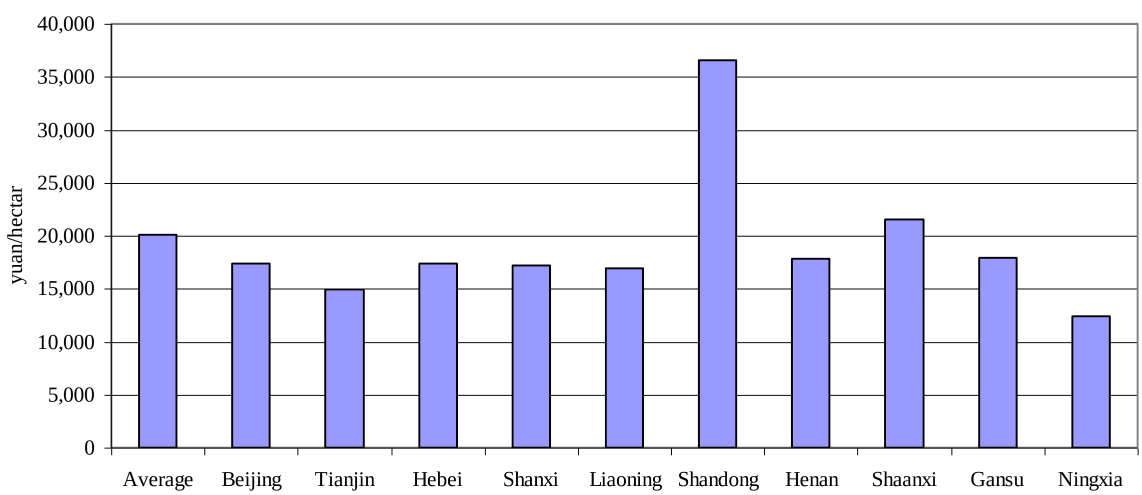
Country	Labor	Materials	Direct Costs	Overhead	Total Costs

			(Dollar/acre)		
High-cost countries					
Italy	2,753	736	3,489	4,298	7,787
France	2,288	492	2,780	2,615	5,395
Germany	1,760	568	2,328	2,773	5,101
USA	2,052	450	2,502	2,502	5,004
Low-cost countries					
Chile	1,045	406	1,450	1,179	2,629
Brazil	586	506	1,092	760	1,853
Poland	325	348	672	1,169	1,842
China	374	587	961	584	1,545

Source: Statement of Nancy Foster, president and CEO of the U.S. Apple Association, 2005

In addition, there are differences in production costs for high-quality apples for export versus average apples in China. Figure 2.2 shows estimates in yuan per hectare of production costs in selected provinces. The average cost is somewhat lower than that estimated by Foster—the average of 20,104 yuan translates into about $983 per acre. But costs are much higher in Shandong Province, estimated at 36,602 yuan per hectare, or about $1,789 per acre.

Figure 2.2. Estimates of Production Costs for Selected Provinces in China, 2004



Source: China Agriculture Yearbook, 2005

The United States

Currently 100 varieties of apples are grown commercially across 36 states in the U.S. with Delicious being the most widely grown variety. Red Delicious and Golden Delicious accounted for 27 percent and 13 percent of the U.S. apple crop, respectively, even though the acreage used to produce these two varieties has been falling.[11] Production of new varieties, such as Fuji and Gala, has expanded in response to opportunities in the major export markets[12] as well as to offer new choices to domestic consumers (Fruit and Tree Nuts Outlook, 2005). Gala and Fuji have become the third and fourth leading apple varieties grown in the U.S.

Apples grow particularly well in the cooler northern states. Washington is the leading apple-producing state, with 40 percent of the total American apple bearing acreage, and producing more than half of the nation's annual output. Washington supplies 65 percent to 75 percent of the apples sold in the U.S. fresh market. It is also the largest fresh apple provider to the processing industry. Michigan, New York, California, Pennsylvania and Virginia are also top apple-producing states. These four states supply 15 percent to 20 percent of the U.S. fresh-market apples and 40 percent to 50 percent of the total processing apples (Fruit and Tree Nuts Outlook, 2005).

The U.S. growers harvested large volumes of fresh apples during much of the 1990s because of improved planting and management practices and a slight expansion in bearing acreage. But by the late 1990s, the large volume of domestic production, increased foreign competition (especially with China), the Asian financial crisis, and an antidumping dispute affecting exports to Mexico depressed the U.S. apple market and reduced the returns to the American apple growers significantly (FAS/USDA, 2003). Apple grower prices reached a low point during that period and many of the apple growers left the industry. According to the most recent agricultural census, the number of U.S. farms that grow apples decreased from 33,835 in 1997 to 26,853 in 2002 (Fruit and Tree Nuts Outlook, 2005). Apple bearing acreage has been declining since then, from 189,230 hectares in 1998 to 160,000 hectares in 2005, as shown in Table 2.3 (FAOSTAT, 2006). Total apple production in the U.S. declined with acreage and the U.S. apple crop in 2002/03 was only 3.9 million metric tons, the lowest record since 1988/89 when production was only 3.8 million metric tons (FAS/USDA, 2003). Decreased apple yields

[11] The shares of Red Delicious and Golden Delicious in the U.S. apple production were 44 percent and 16 percent, respectively, in the early 1990s.
[12] The major export markets refer to East Asia, where Fuji and Gala are popular.

contributed to a continued depression in the overall U.S. apple market, which in turn intensified the decline in the apple bearing acreage. Yield and production subsequently recovered in 2004 and 2005.

Table 2.3. U.S. Apple Production, Yield and Acreage, 1998-2005

	1998	1999	2000	2001	2002	2003	2004	2005
Production (000 MT)	5,283	4,822	4,682	4,277	3,866	3,989	4,726	4,254
Yield (kg/hectare)	27,916	25,858	26,923	25,280	24,200	25,242	30,250	26,589
Acreage (hectares)	189,230	186,486	173,900	169,179	159,770	158,010	156,245	160,000

Source: FAOSTAT, 2006

About 60 percent of U.S. apple production is utilized as fresh fruit. The remaining 40 percent is processed into apple products, of which 21 percent are for juices and ciders. The share of fresh-market production has been increasing in recent years compared to processing production as the imports of low-priced Chinese apple juice concentrate drove down the price for juice apples significantly and made the fresh market relatively more profitable. Antidumping duties were imposed on imported Chinese apple juice concentrate under an ITC decision in 2000 (US Apple Association News Release, 2002), but there remains a price gap favorable to fresh apple production. During 2002-2004, growers were paid over 20 cents per pound more annually for the fresh apples (Fruit and Tree Nuts Outlook, 2005).

Production levels and producer prices during 2002-2004 are shown for several leading apple producing states in Table 2.4. Preceding high production in 2001 led to low prices during 2002 which rebounded in 2003 and 2004 as production levels declined due to unfavorable weather and poor returns to apple growers (Fruit and Tree Nuts Outlook, 2005). Apple growers were paid highest prices per pound in western Washington, California and New York and lowest in other eastern and central state, such as Pennsylvania, Michigan and Virginia. Washington apple growers received the best average return for their apples (20.7 cents/lb) during 2002-2004 with a clear reflection of the price moving inversely with the level of output.

Table 2.4. U.S. Apple Production and Season-average Grower's Prices for Major Apple-producing States, 2002-2004

States	Production				Price		
	2002	2003	2004	2005	2002	2003	2004
	Million pounds				*Cents per pound*		
Eastern States	1,795	2,281	2,500	2,408			
New York	680	1070	1280	1150	17.7	14.5	15.1
Pennsylvania	370	442	405	430	10.1	10.3	10.1
Virginia	250	270	300	320	10.4	9.6	14.9
Central States	821	1,250	1,126	1,154			
Michigan	520	890	760	820	12.4	11.7	11.9
Western States							
	5,908	5,262	6,795	6,275			
California	470	450	390	410	20.4	17.8	15.0
Washington	5,100	4,550	6,050	5,600	20.1	25.9	15.9
U.S.	See Table 2.4				15.8	18.9	20.9

Source: Fruit and Tree Nuts Outlook, ERS/USDA, 2005
Note: Production in 2005 estimated using original data from National Agricultural Statistics Services, USDA.

Partly in response to the difficulties in the apple industry, agricultural disaster relief legislation enacted by the U.S. Congress in February 2003 included coverage for all U.S. fruit growers who experienced at least 35 percent losses in the years 2001 to 2002. Apple growers and other specialty crop groups who suffered weather-related disaster losses during specified seasons were entitled to disaster payments (FAS/USDA, 2003).

The better prices for apples in 2003 combined with the disaster payments offered by the government improved grower returns. Apple production in the U.S. rose to 4.7 million metric tons in 2004/05, a 10 percent increase from the previous year; with yields up but acreage continuing to decline slightly. Washington and New York apple production increase most, by 30 percent and 11 percent, respectively. This increase offset the drop in the apple supply from Michigan and California. The total apple supply decreased again (by 0.5 million tons) in the marketing season 2005/06 due to lower yields even though acreage increased from 156,245 to 160,000 hectares.

European Union

In the European Union (EU), France, Italy, Germany and the new member Poland are among the leading apple producing-countries in the world.[13] Golden Delicious, Jonagold, Red Delicious, and Gala are the major apple varieties produced. New varieties, such as Braeburn and Fuji, are making inroads in Europe in response to consumers' changing preferences.

Apple production in France is concentrated in the western region. Golden Delicious is the major variety produced, representing 60 percent to 75 percent of the total French apple production (FAS/USDA, 2003). The volume of apples supplied by France fluctuated during 1990-1995, then declined slightly and became stable at 2.2 to 2.4 million tons since 1998. A steady decrease in the French apple bearing acreage has continued since the 1980s. The total harvested area for apples in France was only 58,000 hectares in 2005, less than two-thirds of the area in the early 1990s (FAOSTAT, 2006).

Italian apple production is concentrated in the Trentino-Alto region, which produces nearly 60 percent of the overall Italian apple crop. Red and Golden Delicious are the largest varieties grown, accounting for more than two-thirds of the total Italian apple supply (FAS/USDA, 2003). Italian apple production has been fluctuated in the past fifteen years with the largest supply occurred in 1999 (2.3 million metric tons) and the lowest in 2003 (only 1.6 million metric tons). The apple yield in this country increased significantly, from 23,602 kilogram/hectare in 1991 to 35,575 kilogram/hectare in 2005. But the apple bearing acreage decreased from 77,000 hectares to 61,000 hectares (FAOSTAT, 2006). The decline of apple acreage as well as the unfavorable weather condition explained the decrease in the Italian apple output during 2001 to 2003.

Apples are one of the most important fruit crops in Germany. German apple production has fluctuated during the past 15 years. Its apple supply was over 3 million metric tons in 1992 and 2000 but less than 1.5 million tons in other specific years. Like other European countries, the German apple yield shows an increasing trend as well as substantial annual fluctuations, whereas

[13] The European Union (EU), formerly known as European Economic Community, was founded on November 1, 1993 with twelve members including Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and the United Kingdom. New members (Austria, Finland, Sweden) joined EU on January 1, 1995. Finally ten Eastern Europe countries (Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia) became members of the EU on May 1, 2004. The discussion of EU apple production here focuses on France, Italy, Germany and Poland, the major apple-producing countries.

the acreage is declining. Since 2000, the apple acreage in Germany has been maintained around 70,000 hectares (FAOSTAT, 2006).

An increase in the apple volume supplied by Poland has been due to the large land area suitable for growing apple, improvements in infrastructure, and low production costs. Polish apple production experienced a significant increase in 2001 and the supply has been stable at the larger amount since then, although a decrease was observed in 2005. Most apple production in Poland is undertaken on a low intensity basis (Rabobank, 2006). Moving toward a higher intensity production pattern will further improve apple production in Poland. About 60 percent of the Polish apple crop is processed and 90 percent of its processed apple juice is exported to neighboring countries. Poland is unique in positioning itself as a major international supplier of apple juice.

Southern Hemisphere Countries

Southern Hemisphere producers play an important role in world apple markets because of the seasonality of their production even though they contribute a relatively small amount of total global apple production. Northern Hemisphere apple imports from southern hemisphere countries are mainly from April through August. The total production shares in the Southern Hemisphere are less than 1 percent for Australia and 2 percent to 3 percent for Argentina. The apples supplied by Chile, New Zealand, Brazil and South Africa are between 1 percent and 3 percent of world totals (FAOSTAT, 2006). In general, the production in the southern hemisphere countries has been relatively stable with a slight rising trend during the last fifteen years. Red Delicious, Granny Smith and Golden Delicious are the traditional major varieties produced. New varieties such as Royal Gala, Fuji, and Braeburn also attract apple growers in the southern hemisphere countries in response to new export market access opportunities.

2.2 Global Fresh Apple Consumption and Trade

Overall, domestic consumption of fresh apples accounts for about 70 percent of the total global apple production each year.[14] The global apple trade has grown, led by growth from China (Figure 2.1), but is still only a small portion of the overall global apple production. The FAO data suggests that around 10 percent of the total global apple production has been exported annually (for fresh consumption or processing by the importer) since 1990.[15] Several of the leading apple exporters are not among the leading producers (Table 2.5 and Appendix I). France led the apple export volume ranking for many years, contributing 13-16 percent of the world apple export volume each year. The EU trade of fresh fruits consists mostly of intra-EU trade among its member countries. French apples are mostly shipped to the United Kingdom (UK) and Germany, but have also been successful in penetrating markets such as Scandinavia, Eastern Europe, Russia and South-East Asia (FAS/USDA, 2003). Italy is the second largest apple exporter in the EU, its major apple buyers are Germany, Austria, and Norway.

France was replaced as the leading apple exporter by China and Chile in 2004 (Table 2.5). A significant increase has occurred in Chinese apple exports since 1998 even though most of the Chinese apple production is consumed domestically and only a small portion (1-4 percent) has been sold abroad. Chinese apple exports increased from 170,000 metric tons in 1998 to 774,000 metric tons in 2004 and correspondingly its share of the global apple exports jumped from 3 percent to 12 percent (FAOSTAT, 2006). Southeast Asia, Russia and Hong Kong are the major export destinations for Chinese apples; exports to these areas account for over 70 percent of the Chinese total. Shandong, Liaoning and Shaanxi are the largest three Chinese provinces that produce exported fresh apples. Over 90 percent of the total apple exports of China are supplied by these three provinces (Gao, 2006).

[14] Some of the consumption data is from Foreign Agricultural Service, U.S. Department of Agriculture (FAS/USDA). Marketing year is used by FAS/USDA to report apple production, supply and distribution in selected countries, which is different from the calendar year used by FAO. The marketing year runs from July to the following June.

[15] Trade of juices and processed apples are excluded.

Table 2.5. Leading Apple Exporters, 2000 and 2004

Ranking	Year 2000 Country	Quantity (000 MT)	Ranking	Year 2004 Country	Quantity (000 MT)
		Leading exporters			
1	France	848	1	China	774
2	USA	662	2	Chile	739
3	Italy	579	3	France	628
4	Chile	415	4	Italy	542
5	New Zealand	374	5	USA	492
6	Belgium	363	6	Poland	407
7	China	298	7	Netherlands	388
8	Netherlands	286	8	New Zealand	358
9	Poland	212	9	Belgium	337
10	South Africa	207	10	South Africa	305
Top-10 Subtotal		3,958			4,970
World Total		59,209			62,556

Source: FAOSTAT Database

China’s apple exports are expected to continue the increasing pattern as the exported fruit quality improves and prices remain competitive. One estimate is for China to capture one-fourth of the global apple trade by 2008 (Gifford, 2005). The growth of Chinese apple exports has challenged the U.S. apple industry as China’s export of fresh apples have displaced U.S. exports, particularly in the Asian markets. More than half of Chinese fresh apples were exported to the ASEAN countries, which was also an important market for the U.S. in Asia. The import share of Chinese apples in five Southeast Asian countries (Indonesia, Malaysia, the Philippines, Singapore, and Thailand) increased from 15 percent in 1997 to 70 percent in 2004; while during the same period, the share of American apples declined from 51 percent to 11 percent. China has surpassed the U.S. as the leading apple supplier to these countries by volume since 1999 (Huang and Gale, 2006).

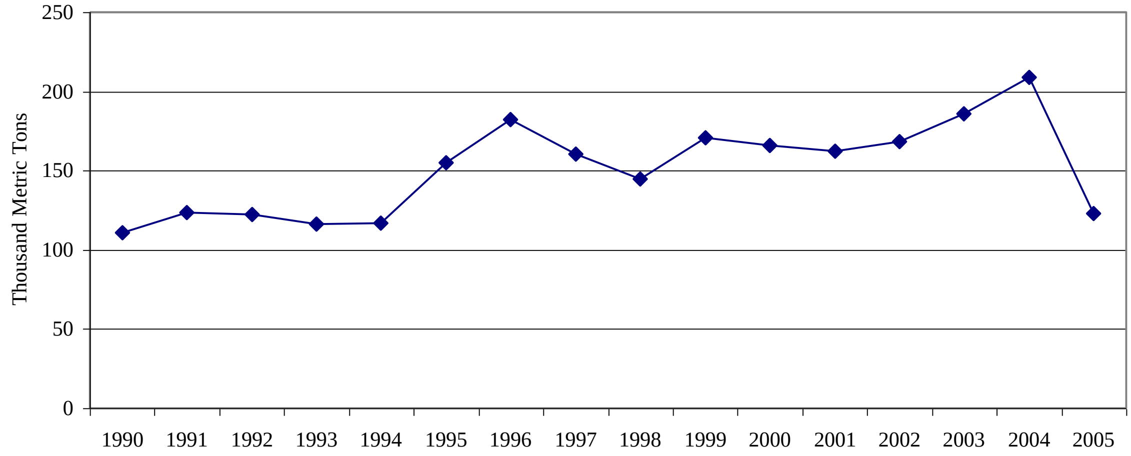
China’s apple imports have also increased due largely to the rising purchasing power of urban consumers. These urban consumers are willing to spend more on domestic and imported fresh fruits as their incomes rise. The increasing import trend is likely to continue with the elimination of more quarantine barriers and increased market access to China. An expansion in Chinese apple trade is expected after China completes trade agreements with some Southern Hemisphere nations. If the bilateral agreements are reached, China will become a likely supplier of out-of-season fruits to these nations and vice versa (Gifford, 2004).

The U.S. is also one of the leading apple exporting countries (Tables 2.5 and Appendix I). The share of U.S. fresh apples going to export markets has increased from an average of 6 percent during the 1970s to 12 percent in the 1980s and to occasional peaks of over 20 percent in the 1990s (ERS/USDA, 2005). The U.S. apple exports accounted for over one-tenth of the total global apple export volume in the 1990s, and it ranked as the second largest apple exporting country worldwide in 2000. But since 2002, there has been a consecutive significant decrease in U.S. apple exports due to the small apple crop in those years and lower exports to Mexico. Apple exports in the U.S. dropped from 715,000 tons in 2001 to 492,000 tons in 2004 and its share of the global apple exports declined from 13 percent to 7.6 percent over the same period (FAOSTAT, 2006).

Most of the U.S. apple exports go to Canada, Mexico, Taiwan and Hong Kong. Red and Golden Delicious are the major varieties exported. Canada is now the top market for the U.S. apples in value terms. U.S. apples account for over 70 percent of the Canadian fresh apple import market. Mexico remains the top market for U.S. apple exports in volume.

U.S. apple imports have increased since the 1990s. In 2004, the U.S. imported 209 thousand metric tons of apples, a 88 percent increase from 1990 (FAOSTAT, 2006; see Figure 2.3 and Appendix I). The imported volume was still small relative to the U.S. domestic production. But the import share of the U.S. domestic fresh apple consumption has risen from less than 5 percent in 1990/91 to 10 percent in 2003/04. Chile has emerged as the biggest supplier of fresh apples to the U.S. as it successfully developed a more export-oriented industry and benefited from the growing demand in the U.S. market for off-season fruit (ERS/USDA, 2005). Chile provides over 40 percent of the total U.S. apple imports annually. New Zealand is the second largest foreign source of fresh apples for the U.S., accounting for about 30 percent of the U.S. apple imports market, while Canada ranks third (COMTRADE, 2006).

Figure 2.3. U.S. Apple Imports 1990-2005



Source: Comtrade, 2006

Trade is of great importance to major Southern Hemisphere apple-producing countries. Their contributions to global apple exports are in the range of 3-5 percent for Argentina and South Africa, 5 -7 percent for New Zealand, and 8-11 percent for Chile, respectively (FAOSTAT, 2006). The EU and the U.S. are the major export markets for Chilean apples, nearly 80 percent of the Chilean apples were exported to these two destinations. Red Delicious is the major variety exported, accounting for about two-thirds of the overall Chilean apple sales overseas. But the share of sweet varieties, such as Fuji, is increasing.

Apples exported from New Zealand are of high quality. The EU and the U.S. are New Zealand's major apple customers. In 2004, of the 393 thousand metric tons of exported New Zealand apples, 49 percent went to the EU and 17 percent to the U.S. Among the EU countries, the UK is the largest buyer; it imported 22 percent of the total New Zealand apple exports during the same year (COMTRADE, 2006). Braeburn and Gala are major varieties exported, representing about 40 percent and 30 percent of the annual New Zealand apple exports, respectively.

World apple markets have become increasingly competitive in recent years. First, this is because the growth of global apple production has been greater than that of the world population. Secondly, production of competing exotic fruits has expanded rapidly since 1990 and there is potential for further increases in the supplies of these other fruits. Increase in demand for these other fruits instead of traditional ones like apples has been a trend in the developed world.

Additional competitive pressure comes from the non-fruit snack items, such as candies, cookies and chips, which have attracted consumers away from fresh apples (Belrose, 2005). Improvement in the apple quality and the availability of new varieties have been ways to retain market opportunities for apple growers.

Apple demand in the developing countries is growing relatively strongly as the population of young people and young households in these countries are growing rapidly. If China continues its economic growth, most of the additional apples produced in China could be consumed domestically (Belrose, 2005). In addition, an increase in incomes will lead to a rise in consumption of high-quality imported apples. Similarly, the large population in India and Turkey consumes most of the domestic apple production in each country. Annual shortage of apples still occurred in India and imports are needed to make up the shortage. The consumption and import potential of these developing counties is substantial. As a result, the apple exporting countries need to be aware of the consumer preferences in these potential apple importing countries and make corresponding adaptive steps in order to penetrate into these markets.

US-China Competition in Canada

Although Canada is not by itself a major country in the world apple markets, it is significant in terms of the issues addressed in this report concerning access of Chinese fresh apples to the North American market. Thus, we provide some details on the Canadian market.

Apples are Canada's most important fruit crop, with the annual value of commercial production much higher than that of other fruits. Apple production in Canada is concentrated in Ontario, British Columbia, Quebec, New Brunswick and Nova Scotia (Canadian Apple Online, 2002). These provinces are along the country's southern edge where the climate is suitable for apple production. Ontario is Canada's largest apple-producing province supplying about 44 percent of the total Canadian apple production. The major apple-producing areas in Ontario spread along the shores of Lake Ontario, Lake Erie, Lake Huron and Georgian Bay. The appropriate temperature, extended growing season and a wide variety of fertile soils results in apples being one of Ontario's biggest and most diverse fruit crops (Gardner, 2004). British Columbia is the second largest apple-growing province in Canada, producing approximately a quarter of the total Canadian apples (British Columbia Ministry of Agriculture, Food and Fisheries, 2005).

McIntosh (35 percent), Red Delicious (11 percent) and Spartan (8 percent) are the major apple varieties produced in Canada, followed by Empire and Idared, each representing about 7 percent of total Canadian production. In recent years, a number of new varieties such as Gala, Fuji, Braeburn, Jonagold, Ambrosia and Honey Crisp have appeared in the Canadian market. The production of these new varieties has expanded as poor returns for the traditional varieties have led Canadian apple growers to plant new varieties with the expectation of higher profitability. Among the new varieties, Gala, Fuji and Ambrosia have been regarded as the most promising ones (Canadian Fruit Situation and Trends, 2001/02). However, due to the increasing availability, grower prices for these newer varieties have moderated significantly. In addition, apples continue to compete for limited retail shelf space with other fruits like bananas and citrus. Increasing supply of exotic fruits also placed a downward pressure on the domestic Canadian apples.

Canadian apple production reached a recent peak in 1999 (Table 2.6). From then on, Canadian apple production has experienced consecutive output reductions and declining acreage. A significant decline was observed during 1999-2002, when apple supply dropped by more than 250,000 metric tons, 66 percent of the total Canadian apple production in 2002 (FAOSTAT, 2006). In 2005, Canadian apple production was 369,500 metric tons, which accounted for 0.6 percent of the total global apple production (FAOSTAT, 2006). Urban pressure on the apple orchard land, higher costs of production, and lower profitability all contributed to the decrease in recent apple production. Competition from foreign sources was also responsible for the significant decrease in the volumes of apples supplied by Canada.

Table 2.6. Canadian Apple Production, Yield and Acreage, 1998-2005

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Production (000 MT)	489	632	543	465	382	379	370	370
Yield (kg/hectare)	18,152	23,821	21,470	19,805	18,551	17,555	17,794	17,794
Acreage (hectares)	26,940	26,547	25,271	23,500	20,584	21,600	20,813	20,766

Source: FAOSTAT, 2006

The significant decrease in the Canadian apple production has resulted in several policy interventions to sustain the industry. These have included interest deferred credit programs for new orchard plantings and a focus on cost-saving and environmental sensitivity through integrated pest management. In addition, apples are among a number of regulated commodities in Canada that have inspection requirements for inter-provincial and international movements. Traditional hand-on inspection methods were time- and labor-consuming which increased the corresponding inspection service costs. In order to reduce such costs, a quality management program based on HACCP principles has been developed as an alternative to the hands-on methods. Under the new program, the apple packer is responsible for implementing and documenting a Quality System to ensure that the fruit quality meet the requirements. Each facility's system would be deemed valid until the next audits made by the Canadian Food Inspection Agency (CFIA). The program is designed to provide the Canadian apple industry with greater flexibility in shipping apples and avoid any compromise in the quality of the product (Canadian Fruit Situation and Trends, 2002/03). Inter-provincial apple trade in Canada is expected to increase under the quality management system and inspection fees to decline.

Canada has exported apples to over 20 countries in the world with the annual average export volume of 70,353 metric tons, representing approximately 10 percent to 20 percent of the total Canadian apple production (FAOSTAT, 2006). Canadian apple exports have decreased significantly since 2003 due to the lower crop production and non-competitiveness of its products in the global market. Canadian apple exports in 2004/05 were less than half of the average level during the mid-1990s (Canada Deciduous Fruit Annual, 2003, 2004 and 2005). The U.S, Mexico and the UK are the three major export markets for Canadian apples.

Canada has imported an annual average of 134,000 metric tons of apples since the marketing year 2000/01 (Canada Deciduous Fruit Annual, 2003, 2004 and 2005). Granny Smith, Red Delicious and Golden Delicious were the most common imported varieties followed by Fuji, Gala, Braeburn and McIntosh. The U.S. is the most important source of fresh apples to the Canadian market (Table 2.7). Since 2001/02, the annual volume provided by the U.S. has been five to eight times of that supplied by Chile, the second largest exporter to Canada. In 2002/03, Canadian imports of the U.S. fresh apples increased by more than 20 percent to 112,417 metric tons as a result of the low domestic Canadian production. Correspondingly, the U.S. market share of the total Canadian fresh apple imports climbed to 78 percent. But in 2003/04, Canada only imported 95,334 metric tons of fresh apples from the U.S. due to intense competition from Chile, South Africa, and newly allowed imports from China. This 15 percent decrease in the volumes of imported U.S. apples resulted in an 8 percent decrease in the U.S. share of the

Canadian apple import markets. In 2004/05, fresh apple imports from the U.S. increased again to 115,002 metric tons, a 20.6 percent rise from the previous year. Because of the strong demand for U.S. apples, imports from Chile, New Zealand and South Africa declined. Apple prices fell to 60 percent of the earlier level (Canadian Fresh Deciduous Fruit Annual, 2005). The significant decrease in the Canadian apple prices severely affected domestic apple growers, who filed complaints against the U.S. apples and pushed for an anti-dumping action.

Table 2.7. Canadian Fresh Apple Imports (metric tons), 2000-2004

Country	2000/01	2001/02	2002/03	2003/04	2004/05
United States	94,844	92,816	112,417	95,334	115,002
Chile	10,904	12,562	14,694	18,596	15,748
New Zealand	7,213	8,331	9,796	9,873	7,027
South Africa	5,252	7,214	5,725	7,412	4,385
China	4	4	427	3,299	3,601
France	1,299	462	894	891	163
Argentina	452	448	680	186	152
World	120,576	122,053	144,768	135,934	146,320

Source: Canada Fresh Deciduous Fruit Annual 2003, 2004 and 2005
Note: Marketing year is July/June.

Under new phytosanitary regulations, as described in the following section, the importation of fresh apples from China became noticeable in 2002/03. In 2003/04, 3,299 metric tons of Chinese fresh apples were imported into Canada, reflecting a 7.7 times increase from the previous year. China became the fifth largest supplier of fresh apples to Canada, providing 2.4 percent of the annual Canadian apple imports. Although fresh apples from Shaanxi province were suspended by CFIA for nine month in 2004 because of the repeated findings of spider mites, imports from China increased to 3,601 tons in 2004/05.[16] Chinese fresh apples were mainly sold to the Asian communities in Canada at a higher price level, as noted earlier.

2.3 The Global Processed Apple Industry

To put the background discussion of world fresh apple market in a broader perspective, we briefly focus on the market for apple juice. Apples can be processed into different products instead of being eaten as fresh fruits. Processed apple products include juice and cider, apple

[16] Fresh apple imports from Shaanxi province was suspended by CFIA on February 17, 2004, the removal of the suspension was on October 11, 2004. Detailed description of the suspension is provided in the next section.

sauce, canned apple, dried apple, apple butter or jelly and vinegar. Juice and cider is the most import segment of the processed apple industry. Of the global annual apple production, 70-80 percent is consumed as fresh apples whereas the remaining 20-30 percent is processed into value-added products (FAS/USDA, 2005).[17] Within these processed apple products, 65 percent are processed into apple juice or apple juice concentrate.[18]

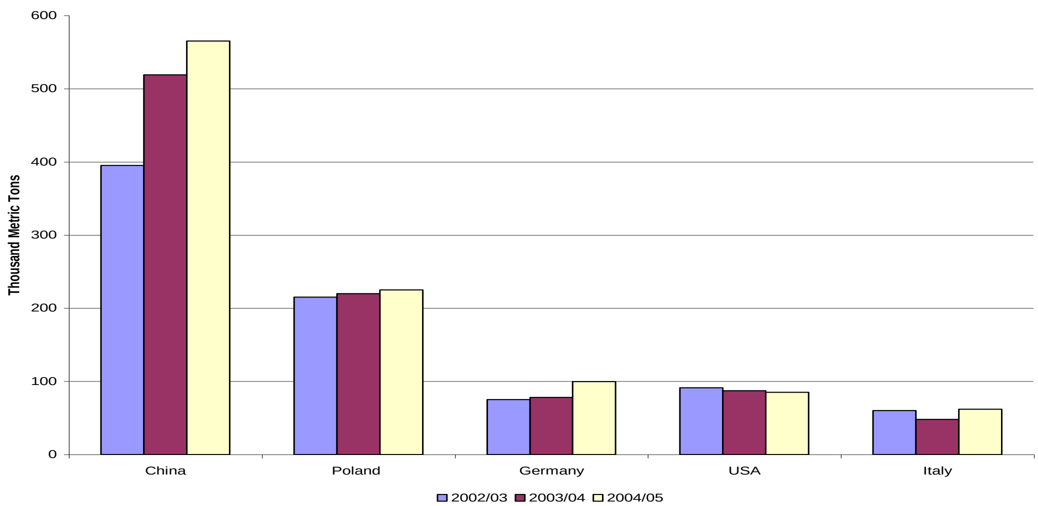
Fresh juice, reconstituted juice and blended juice are the three major forms of apple juice. In addition, apple juice can be used as a base for other juice product and to sweeten some food products. Apple juice can be reconstituted from apple juice concentrate, which is produced from apple juice using water-removal technology. This technology allows for efficient storage and transportation of juices. Apple juice concentrate is available in frozen or non-frozen forms. Some concentrates have added ingredients, such as vitamin C. Apple juice is usually clarified or filtered before bottling. Most apple juice is pasteurized and available in refrigerated and non-refrigerated forms. Pasteurized, non-refrigerated apple juice can have a shelf life of up to two years.

Apple juice is produced around the world in the apple-growing countries. World apple juice production has been increasing since the late 1990s. In the market year 2004/05, global apple juice production reached 1.29 million metric tons (FAS/USDA, 2005). A significant increase in world juice output mainly reflects production in China, the world's largest apple juice producer. China began the production of apple juice concentrate in 1983, when the first concentrate processing system was imported into China. From then on the development of the Chinese apple juice industry has been remarkable. By 2004/05, China had taken 44 percent of the global apple juice production, reaching a record of 565,000 metric tons, more than double the volume produced three seasons earlier (FAS/USDA, 2005, see Figure 2.4). Nearly 85 percent of the Chinese apple juice concentrate is exported abroad, with the major destinations including the U.S., the Netherlands, Japan, Germany, and Australia.

[17] The percentages are calculated using the data from FAS/USDA by dividing the volume of global processed apples over the total global apple production during 1997/98 to 2004/05.

[18] Juice pressed from fresh or stored apples can be made into fresh apple juice, fresh apple cider, apple juice concentrate, and fermented beverages and vinegar. Apple juices and non-alcoholic ciders are made by similar methods; the variation in sugar content and acidity depends on the apple varieties used to produce the juice or cider. The difference between juice and non-alcoholic cider is the fully removal of yeast and mold in the producing process of apple juice (Rowles, 2001).

Figure 2.4: World Leading Apple Juice Producer: 2002/03-2004/05



Source: FAS/USDA, 2005

Besides China, Poland and the U.S. are also leading apple juice producers in the world (Figure 2.4). Poland produced 225,000 metric tons of apple juice in 2004/05, accounting for 17 percent of the world apple juice production. About 95 percent of the apple juice produced in Poland was exported. Germany is the biggest Polish apple juice importer, purchasing more than 80 percent of its apple juice exports. Most of this juice is reprocessed in Germany and re-exported to the U.S. (Rowles, 2001). Germany is also a top apple juice producer in the world and its production has been increasing over the last three decades. In 2004/05, juice production in Germany was 100,000 thousand metric tons, which exceeded the U.S. production and Germany became the third largest apple juice producer (FAS/USDA, 2005).

Apple juice production in the U.S. has been declining in the past few years. In 2004/05, total U.S. apple juice production was only 85,000 metric tons, accounting for less than 7 percent of the world production (FAS/USDA, 2005). Most of the apple juice produced in the U.S. was consumed domestically. Canada and Japan are the largest importers of U.S. apple juice. However, with the decrease in apple juice production, U.S. apple juice exports have also been decreasing in recent years.

Argentina and Chile are the two largest apple juice producers in the Southern Hemisphere. Their production in 2004/05 was 69,000 and 51,500 metric tons, respectively (FAS/USDA, 2005). Like China and Poland, these two countries export most of their apple juice production, mainly to the U.S. More than 95 percent of annual Argentinean apple juice output is shipped to the U.S.

The U.S. is the world's largest apple juice importer and U.S. import demand continues with an upward trend. U.S. imported apple juices are mostly concentrated and non-frozen. In response to the surge of low-priced apple juice from China, the U.S. imposed antidumping duties on imports of Chinese non-frozen apple juice concentrate, which ranges from 3.83 percent to 51.74 percent (FAS/USDA, 2006).[19] The antidumping duties have been in effect since May 2000 (Gentry, 2000) and was set to expire in 2005. The ITC and USDC reviewed the antidumping order imposed on Chinese apple juice concentrate and determined to remain the existing order in place on September 19, 2005, so as to prevent the continuation of the injury of low-price Chinese apple juice concentrate on the US apple juice production. (FAS/USDA, 2006)

[19] Before 1995, China accounted for less than 1 percent of the apple juice imported by the U.S. However, from 1995 to 1998, U.S. imports of Chinese concentrate increased from 3,000 metric tons to 40,000 metric tons. Correspondingly, the Chinese share of the U.S. concentrate market rose from 1 percent in 1995 to 18 percent in 1998. During the same period, the average price of Chinese concentrate imports dropped by more than 53 percent, from $7.65 per gallon in 1995 to $3.57 per gallon in 1998. Between 1995 and 1998, the average price for U.S.-made apple juice concentrate fell by 50 percent. The prices for juice apples dropped by 64 percent, from $153 per ton in 1995 to $55 per ton in1998. The U.S. Department of Agriculture estimated apple growers lost more than $135 million in revenue from 1995 to 1998.

2.4 Fresh Apple Trade Disputes

Fresh apple trade is subject to phytosanitary regulations, periodic disputes about dumping as production levels and prices vary across years, and standard tariffs of different levels among countries. This section illustrates the types of phytosanitary issues that have arisen with an emphasis on intra-North American trade and exports from the U.S. Section 3 describes in depth some of the phytosanitary decision making with respect to China's exports of apples and pears into Canada, the U.S. and a few other countries. Tariff levels are described when a benchmark data set is constructed for the economic modeling in section 5.

Antidumping Cases

Dumping disputes have marked the apple trade between the U.S. and Mexico for a long time. In 1997, the Mexican government started an investigation of the U.S. apples in response to the dumping charges claimed by the Mexican growers. An initial duty rate of 101.1 percent was imposed on the imported U.S. apples in September 1997. This duty was lifted in 1998 based on a U.S./Mexico apple dumping suspension agreement. But in August 2002, Mexico revoked the suspension decision and resumed a new duty rate on the U.S. apples on September 30. Red and Golden Delicious apples were subject to an antidumping duty of 46.58 percent (FAS/USDA, 2005). U.S. exports declined significantly in the following marketing year.

Exports of U.S. apples faced similar challenges in Canada during the mid-1990s. In 1994, the Canadian apple industry claimed that the U.S. apples were sold to Canada at prices below the estimated total costs of growing, packing and marketing, which could be regarded as dumping behavior. Evidence showed that the average price for all grades of Red Delicious apples in Canada decreased by 27 percent during February to May 1994 compared to the same period in 1993. This led to substantial increases in the American apple imports and lower return for Canadian apple growers (Canada Border Services Agency, 1994). In 1995, U.S. Delicious apples were subject to a special antidumping duty rate, which was rescinded in 2000. In 2005, the Canadian apple growers pressed the government again for safeguard measures on low-priced U.S. fresh apples and a new investigation of the U.S. dumping behavior was initiated (FAS/USDA, 2005). The new complaint came from the fact that the U.S. fresh apples had taken nearly 80 percent of the Canadian annual imports in the most recent years. At the same time, the

U.S. requested an update of the possible anti-dumping duty imposed on American apples from Canadian government and stressed the necessity of the cooperation of both countries to avert any future trade action. (FAITC, 2005) The anti-dumping case against U.S. apples did not lead to additional duties being applied.

Phytosanitary Barrier Cases

Phytosanitary regulations are also conspicuous in world apple trade. In 1994, Japan opened its market to the U.S. fresh apples after a long ban. But the U.S. apples were subject to a restrictive phytosanitary protocol to be exported to Japan. The purpose of the protocol was to prevent the import of fire blight and codling moth into Japan. The costly and risky phytosanitary requirements impeded the trade between the U.S. and Japan. In fact, no U.S. apples were exported to Japan in 1998 (Calvin, Krissoff and Foster, 2007).

The U.S. has long argued against Japan's plant quarantine regulations with regard to the import procedures on the U.S. apples for fire blight and filed a complaint with the WTO in March 2002. In June 2003, a WTO panel issued a final report concluded that Japan’s measures were not consistent with the WTO SPS Agreement as they were not supported by scientific evidence, and were more trade restrictive than required (FAS/USDA, 2005). After several rounds of negotiations Japan eliminated the scientifically-unjustifiable restrictions that were related to fire blight on U.S. apples effective August 25, 2005 (ERS/USDA, 2005). The removal of these stringent regulations would lower the U.S. apple growers’ compliance costs and the U.S. exports to Japan were expected to increase. However, little trade has occurred due to remaining compliance costs and uncertainty about quality of apple production and import prices relative to domestic U.S. prices ((Calvin, Krissoff and Foster, 2007).

In December 2004, Taiwan banned U.S. apple imports after the third detection of codling moth. In order to reopen this important Asian market, the U.S. submitted an apple work plan to the Minister of the Council of Agriculture (COA) in Taiwan in March 2005. Officials from the Taiwan Bureau of Animal and Plant Health Inspection and Quarantine (BAPHIQ) traveled to Washington State to inspect orchards and review the codling moth detection system. Assured that the newly developed mitigation measures were effective in controlling codling moth larvae in apples, the ban was lifted in April 2004 (FAS/USDA, 2005). The four-month ban did not have a large impact on U.S. exports to Taiwan. In the marketing season 2004/05, Taiwan remained the third largest importer of U.S. fresh apples.

In March 2005, India began sample testing the U.S. apples that entered the port of Mumbai. The testing was aimed at detecting the presence of wax coatings containing animal-based ingredients on the imported U.S. apples. India first announced an intention of imposing a ban on the sales of imported fresh fruits and vegetables (including fresh apples) coated with such waxes in October 2003. Although the ban had not been enforced, its potential enforcement continues to be of great concern to the U.S. exporters. Therefore the U.S. has requested India to approve the use of carnauba wax and shellac on the U.S. fresh fruits and vegetables (FAS/USDA, 2005).

Phytosanitary barriers have also impeded the apple trade between Canada and Mexico. Canadian apples were banned by the Mexican government in 1995 due to phytosanitary concerns. With changes in Mexican phytosanitary requirements, Canadian apples were permitted entry again two years later. In addition, the Mexican government has implemented tariff elimination on agri-food products under NAFTA since 2003. Fresh Canadian and U.S. apples are given duty free access into the Mexican market (abstracting from any anti-dumping or other special duties), giving them a competitive advantage.

Appendix I: World Apple Production and Trade

Table AI.1. World Apple Production (thousand metric tons), 2001-2005

Country	2001	2002	2003	2004	2005
Northern Hemisphere					
Selected Countries in Europe					
Belgium	337	349	319	356	325
France	2,397	2,432	2,137	2,204	2,246
Germany	1,779	1,471	818	980	891
Greece	248	281	208	275	250
Italy	2,299	2,199	1,954	2,136	2,192
Netherlands	408	354	359	436	359
Spain	917	695	881	691	770
United Kingdom	212	179	144	170	219
Hungary	605	527	508	700	510
Poland	2,434	2,168	2,428	2,522	2,075
Russia	1,640	1,950	1,690	2,030	2,050
Sub-total Europe	16,418	16,206	15,745	16,926	15,695
Selected Countries in North America					
United States	4,277	3,866	3,948	4,700	4,428
Canada	465	382	379	370	409
Mexico	443	480	495	573	584
Sub-total North America	4,742	4,248	4,326	5,070	4,837
Selected Countries in Asia					
China	20,023	19,251	21,105	23,682	24,018
Turkey	2,450	2,200	2,600	2,100	2,570
Iran	2,353	2,334	2,400	2,179	2,662
India	1,230	1,160	1,470	1,353	1,353
Japan	931	926	842	755	819
Sub-total Asia	30,112	28,996	31,526	33,333	34,825
Southern Hemisphere					
Argentina	1,429	1,157	1,307	1,262	1,272
Brazil	716	857	842	980	851
Chile	1,135	1,150	1,250	1,300	1,350
Sub-total South America	3,976	3,874	4,160	4,384	4,340
New Zealand	474	531	501	546	524
Australia	325	321	326	255	327
Sub-total Oceania	799	852	828	802	851
South Africa	563	591	702	765	680
Sub-total Africa	1,496	1,745	1,783	2,041	1,915
World	57,543	55,921	58,369	62,556	62,463

Source: FAOSTAT database

Table AI.2. World Apple Exports (thousand metric tons), 2001-2005

Country	2001	2002	2003	2004	2005
Northern Hemisphere					
Selected Countries in Europe					
Belgium	271	318	289	297	289
France	729	718	767	616	627
Germany	82	78	89	116	118
Greece	44	18	31	30	46
Italy	513	604	669	512	670
Netherlands	263	302	329	406	413
Spain	77	96	71	109	101
United Kingdom	16	16	17	19	19
Hungary	23	10	8	16	42
Poland	117	310	341	410	423
Russia	1	2	8	3	6
Sub-total Europe	2,345	2,708	2,981	2,901	3,162
Selected Countries in North America					
United States	706	583	529	487	684
Canada	60	63	51	45	54
Sub-total North America	766	645	581	533	738
Selected Countries in Asia					
China	304	425	601	763	832
Turkey	19	10	16	17	24
Iran	99	107	123	126	137
India	19	16	9	23	30
Japan	2	10	16	11	17
Sub-total Asia	606	683	898	1,134	1,265
Southern Hemisphere					
Argentina	195	166	201	196	261
Brazil	35	63	76	141	96
Chile	552	568	601	707	611
Sub-total South America	789	807	888	1,054	986
New Zealand	217	263	255	270	258
Australia	33	26	31	10	14
Sub-total Oceania	249	288	286	281	272
South Africa	255	269	310	298	253
Sub-total Africa	269	273	327	320	273
World	5,024	5,404	5,961	6,222	6,695

Source: FAOSTAT database

Table AI.3. World Apple Imports (thousand metric tons), 2001-2005

Country	2001	2002	2003	2004	2005
Northern Hemisphere					
Selected Countries in Europe					
Austria	87	72	74	76	88
Belgium	143	141	158	131	153
France	111	138	124	207	193
Germany	663	808	846	766	807
Greece	24	39	40	36	27
Italy	35	51	54	86	53
Netherlands	299	332	418	389	362
Spain	188	216	246	254	244
United Kingdom	467	455	486	515	518
Russia	314	379	566	668	702
Sub-total Europe	3,021	3,360	3,856	3,942	4,165
Selected Countries in North America					
United States	162	168	186	209	123
Canada	122	148	144	135	152
Mexico	232	178	176	152	187
Sub-total North America	284	317	330	344	275
Selected Countries in Asia					
China	244	257	246	236	264
India	19	20	21	22	36
Indonesia	82	89	80	114	126
Malaysia	91	89	96	107	109
Philippines	48	54	74	55	66
Saudi Arabia	117	122	120	132	135
Thailand	46	48	77	78	87
Vietnam	12	46	64	93	100
Sub-total Asia	1,018	1,106	1,163	1,346	1,549
Southern Hemisphere					
Brazil	68	54	41	43	68
Columbia	53	51	46	50	56
Sub-total South America	575	457	405	402	500
Egypt	41	29	25	49	45
Sub-total Africa	121	157	157	180	198
World	5,023	5,401	5,917	6,220	6,693

Source: FAOSTAT database

3. Elements of a Hypothetical Regulation for U.S. Imports of Chinese Fresh Apples[20]

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS agreement) was negotiated during the Uruguay Round of the GATT and implemented by the WTO in 1995. It provides guidelines for WTO members for the application of sanitary and phytosanitary measures to protect human, animal and plant life and health, and to help ensure that food is safe for consumption (WTO, 1995).[21] Importing countries usually sign bilateral protocols with an exporting country to control the risk of introducing exotic invasive species. Like other trade barriers, these SPS measures influence patterns of trade and can affect a country's national welfare. Implementing SPS measure can increase corresponding costs from the exporting country or prohibit entry of a product, providing an opportunity for a government to potentially use SPS barriers to isolate domestic industries from international competition (Thornsbury and Minton, 2003). Under the WTO, a challenge faced by policymakers when designing SPS measures to mitigate the risk of introducing exotic invasive species is to reach an appropriate level of protection (ALOP) without imposing high compliance costs that are unduly restrictive to trade.[22]

There are a number of policy measures which can be employed to manage invasive species risk.[23] One approach, gaining in frequency of use, has been referred to as a "systems approach." The systems approach (SA) is a multi-step set of phytosanitary procedures, at least two of which have independent effects on mitigating pest risk associated with the movement of commodities (USDA/APHIS/PPQ, 2002). The systems approach is recommended by the WTO as one option for pest risk management. The difference between the systems approach and other pest risk mitigation measures is that the required measures in a systems approach are multiple and at least some have independent effects on risk probabilities. The number of measures included in any particular systems approach is a critical decision. It is dependent on pest and risk

[20] This section is drawn primarily from chapter 4 in Gao (forthcoming, 2008).

[21] The SPS agreement provides the general guidelines rather than specific numerical limits, such as those set for tariffs under the Agreement on Agriculture.

[22] Appropriate Level of Protection (ALOP) or an acceptable level of risk is defined by the SPS agreement as "the level of protection deemed appropriate by the member establishing a sanitary or phytosanitary measure to protect human, animal, or plant life or health." The SPS Agreement recognizes and maintains the right of countries to determine and set what is an appropriate level of protection for them, while containing several disciplines to prevent countries from setting their levels of protection in an arbitrary or discriminatory fashion (USDA/APHIS, 2007a).

[23] For example, product bans can be used to prohibit or restrict entry of foreign pests.

conditions within the trading countries and can be difficult to evaluate for policymakers. Too few measures will fail to protect human, animal or plant health or the domestic environment from exotic invasive species damage. Too many measures will raise the cost and lead to unnecessary impediments to trade.

In this section, we examine the recent history of phytosanitary rule making related to fresh apples and pears from China by the United States, Canada and several other countries. This overview of recent regulation provides background about pest risks, risk assessments, and risk mitigation measures adopted. We organize the review around the concept of specifying a hypothetical systems approach to pest risk management that might be adopted should the US determine that under such measures fresh apples could be imported from China at an acceptably low level of risk.

To develop such a hypothetical systems approach, we draw on the steps contained in current existing similar pest risk management strategies and corresponding pest risk assessments (PRAs). Under the WTO rules, a pest risk assessment is the basis for establishing phytosanitary regulations among trade partners. We examine the various phytosanitary measures included in the relevant current regulations to determine the common measures (steps) being used in mitigating the risk of introducing pest associated with the apples or pears from China. We qualitatively define these different kinds of measures according to conclusions from existing PRAs. To develop a hypothetical system approach for potential U.S. apple imports, we do not attempt to determine the validity of risk reduction or pest exposure probabilities related to individual steps already in use for other like-policies. Rather, these scientific results-to-date that have been accepted within the political process for current pest risk management regulations and policies related to export of Chinese apples and similar fruit to other markets are being used as references for the hypothetical U.S. systems approach.

3.1 Review of Existing Regulations

Criteria used to identify existing regulations as reference policies include: first, the selected regulations or protocols should be similar to the systems approach systematically and theoretically. The systems approach is based on the International Standard of Phytosanitary Measures (ISPMs) and recommended by the WTO. Our references need to follow ISPMs or other similar alternative standards recommended. Second, selected regulations or protocols should govern trade of Chinese fresh apples or similar fresh products, such as pears. Since no fresh apples are currently exported to the United States from China, it is reasonable to consider the regulations related to Chinese fresh pears within the reference. Chinese fresh pears are among the few fresh fruits that are currently exported from China into the United States. Therefore, there already exists a systems approach, under which Ya pear and Fragrant pear trade is regulated. Most of the Ya pears exported from China to the U.S. are from the same production region as fresh apples. Production conditions, weather conditions, government policies and domestic inspection procedures for apples and pears are quite similar. Regulations from other countries that currently import Chinese fresh apples and pears are also included as references (Table 3.1). Canada, Australia and Argentina, whose horticultural markets are fairly similar to U.S., all import one or both of these products from China.

Table 3.1. References for a Hypothetical U.S. Systems Approach for Chinese Apples

County	Year	Policy
United States	1994	Decision on Entry Status of Fruits and Vegetables, Under Quarantine No.56: Ya Pears (Pyrus bretscheideri) and Sand Pears (Pyrus pyrifolia), Peoples Republic of China (USDA/APHIS, 1994)
	1997	Importation of Fragrant and Ya Pear fruit from China into the United States: A supplemental pest risk assessment (Cave and Lightfield, 1997)
	2003	Removal of cold treatment requirement for Ya pears imported from Hebei province in China (USDA/APHIS, 2003a)
	2005	Information memo for the record (Podleckis and Usnick, 2005)
	2005	Administrative instructions: conditions governing the entry of Ya variety pears from China (USDA/APHIS, 2005a)
	2005	Importation of Fragrant Pears From China (USDA/APHIS, 2005b)
Australia	1998	Final import risk analysis of the importation of fruit of Ya pears (Pyrus bretschneideri Redh.) from the People's Republic of China (Hebei and Shandong provinces) (AQIS, 1998)
	2003	Import of asian ('Shandong') pear (Pyrus pyrifolia (Burm.) Nakai and P. ussuriensis var. viridis T. Lee) fruit from Shandong province in the People's Republic of China (Biosecurity Australia, 2003)
	2005	Draft extension of existing policy for pears from The People's Republic of China (Biosecurity Australia, 2005a)
	2005	Final extension of policy for the importation of pears from the People's Republic of China (Biosecurity Australia, 2005b)
Canada	2007	Plant protection import requirements for fresh apples (Malus spp.) from the People's Republic of China (CFIA, 2007a)
	2007	Interim Policy for plant protection import requirements for fresh pears from China (CFIA, 2007b)
Argentina	2005	Protocol of phytosanitary requirements for the apple and pear fruits export from China to Argentina between the Secretariat of Agricultural, Livestock, Fisheries and Food of the Argentine Republic and the General Administration of Quality Supervision, Inspection, and Quarantine of the People's Republic of China (SENASA, 2005)

Source: Authors' compilation.

Regulation for U.S. Imports of Chinese Ya Pears and Fragrant Pears

China is the world's leading pear producing country. Ya pear is the most popular variety grown in China, accounting for about 30 percent of production.[24] The only two pear varieties that can currently be exported to the U.S. are Ya pears from Hebei and Shandong provinces, and Fragrant pears from Xinjing Province. Chinese plant quarantine officials began negotiating the opening of U.S. markets to these pear varieties in the early 1990s (Table 3.2). In 1995, Ya pear imports from only the province of Hebei were approved under a systems approach for pest risk mitigation and trade began in 1997.

[24] "Ya" means duck in Mandarin dialect of Chinese.

Table 3.2. Summary of Regulations for Chinese Ya Pear and Fragrant Pear Exports to the U.S.

Variety	Date	Event
Fragrant Pears	1993	China started negotiating opening of the U.S. market
	1994	USDA/APHIS/PPQ conducted a PRA for Chinese Fragrant pears
	August 1999	USDA delegation visit Xinjiang province of China
	December 2005	China and the U.S. singed the "Work Plan of Plant Quarantine of Chinese Fragrant Pears to the U.S."
	August 2006	A U.S. technical delegation visited the Xinjiang province in China and USDA finally approved the export of Fragrant pears into the U.S.
Ya Pears	Early 1990s	China initiates request for export of Ya pears to the United States
	1995	Under a systems approach, export of Ya pears from Hebei Province to U.S. was approved
	1997	Ya pears from Hebei Province were imported
	March 2001	U.S. banned further imports due to the disease *Alternaria* sp.
	May and September 2002	USDA/APHIS delegation visited Hebei and Shandong provinces in China
	October 2002	China and the U.S. sign the 2002-2003 Work Plan of Plant Quarantine of Chinese Ya Pear Export to the U.S. Export of Ya pears from Shandong province to the U.S. approved
	November 2002	Ya pear imports from Hebei Province resumed
	June 2003	USDA removed the cold treatment requirement for Ya pears from the Hebei province; Ya pears from Shandong Province still required to undergo cold treatment
	December 19 2003	USDA suspends indefinitely the import, sale and distribution of Ya pears from China
	April 2005	China and the U.S. singed " The 2005/2006 Work Plan of Plant Quarantine of Chinese Ya Pear Export to the U.S. "
	September 2005	USDA delegation found symptoms of *Alternaria* sp. and the U.S. continued to ban the importation
	Late 2005	China and the U.S. signed the supplemental provisions during the Fourteenth China-U.S. Bilateral Meeting on Plant Quarantine held in the U.S.
	February 2006	The U.S. reopened the market to Chinese Ya pears

Source: Authors' compilation.

In early 2001, there was one report of a new disease species of *Alternaria sp.*, *A. yaliinficiens* causing black spots on the fruit (see Roberts, 2005) in the Ya pears exported from Hebei Province.[25] In March 2001, the U.S. banned imports of Ya pear from China. In 2002, a

[25] The disease *Alternaria sp.* is commonly found in outdoor air, on many kinds of plants and foodstuffs and prefers rotting farmland manure. The main symptom is small, round, black spots on leaves, shoots, and the surface of the

technical team from USDA/APHIS visited the Ya pear production orchards in both Hebei and Shandong Provinces. During the visit, the delegation assessed post-harvest mitigation measures associated with black spots in the two production areas. After agreeing on the post harvest mitigation measures, the resumption of the Hebei Ya pear export program and the initiation of a new Ya pear export program from Shandong Province were approved in October 2002 under a bilateral agreement ("The 2002/2003 Work Plan of Plant Quarantine of Chinese Ya Pears to the U.S."). In November, over 2,000 tons of Ya pears grown in Hebei province of China were exported to the U.S. via Tianjin port.

On June 9, 2003 USDA/APHIS removed the cold treatment requirement for Ya pears from the Hebei Province in China after receiving data indicating that no Oriental fruit fly had been found in Hebei Province since 1997. On December 9, 2003, during the period of China premier Wen Jiabao's visit to the U.S., AQSIQ and the USDA signed "The 2003/2004 Work Plan of Plant Quarantine of Chinese Ya Pears to the U.S." However, less than one month later, on December 19, 2003, USDA/APHIS prohibited indefinitely the import, sale and distribution of Ya pears from China upon detection of serious fungal disease infestation. The USDA Agricultural Research Service Tree Fruit Research Laboratory in cooperation with the Plant Protection and Quarantine (PPQ) National Identification Services of USDA's Animal and Plant Health Inspection Service (APHIS) determined that the 2001-2003 detection of the previously undefined *Alternaria* sp. that causes Ya pear fungal infection is a new pathogenic species that is not present in the United States. After two years of negotiations, in April 2005, China and the U.S. signed "The 2005/2006 Work Plan of Plant Quarantine of Chinese Ya Pear Export to the U.S." According to the work plan, a USDA delegation would visit China to investigate the disease *Alternaria* sp. During the visit in September 2005, the USDA/APHIS delegation found disease symptoms in eight orchards in China and the U.S. continued to prohibit importation. In late 2005, during the Fourteenth China-U.S. Bilateral Meeting on Plant Quarantine, China and the U.S. signed the supplemental provisions to the 2005/2006 Work Plan which indicated that the U.S. might open the market again with stricter phytosanitary requirements. In February 2006, the U.S. finally reopened the market to Chinese Ya pears.

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fruit (Roberts, 2005). The disease poses a significant risk to the U.S. apple and pear industry but does not affect human health (USDA/APHIS, 2003b).

Another variety of pear allowed to enter the U.S. market is Fragrant pears from Korla area in Xinjiang province. Early in 1993, China began negotiating the opening of the U.S. market to Chinese Fragrant pears and kept providing materials and data to show that it had low risk of introducing invasive species. In 1994, APHIS/PPQ conducted a pest risk assessment for Chinese Fragrant pears. During bilateral meetings in 1997 and 1998, China further requested the opening of the U.S. market and USDA/APHIS required evidence that there were no pests other than those listed in the original 1994 pest risk assessment. In late August 1999, a U.S. delegation visited Xinjiang province of China and in 2001 finished a report entitled “Program Analysis: Pest Risk of the Export of Fragrant Pears from the Production Areas of Korla, China to the U.S.” In December 2005, after almost thirteen years of negotiation, China and the U.S. signed the “Work Plan of Plant Quarantine of Chinese Fragrant Pears to the U.S.” In August 2006, a USDA delegation visited the orchards and packinghouses again in Xinjiang province and finally approved fragrant pears to enter the U.S. market.

Based on the discussion above, we include the following U.S. regulations related to Chinese Ya pears and fragrant pears among our references (see Table 3.1):

1. *Decision on Entry Status of Fruits and Vegetables, Under Quarantine No.56: Ya Pears (Pyrus bretscheideri) and Sand Pears (Pyrus pyrifolia), Peoples Republic of China* (USDA/APHIS, 1994).
2. *Importation of Fragrant and Ya Pear Fruit from China into the United States-A Supplemental Pest Risk Assessment* (Cave and Lightfield, 1997). This pest risk assessment, conducted by USDA/APHIS/PPQ, supplements the September 1994 assessment. The pest risk assessment provides the qualitative results of pest risk in terms of high, medium and low for Chinese Fragrant pears and Ya pears and also provides the pest risk potential, economic importance and likelihood of introduction and the necessity of phytosanitary measures.
3. *Removal of Cold Treatment Requirement for Ya Pears Imported from Hebei Province in China* (USDA/APHIS, 2003a). This regulation explains the reasons why USDA removed the cold treatment requirement for import of Chinese Ya pears from Hebei province. Since 1997, the export of Chinese Ya pears from Hebei and Shandong provinces should be cold treated in-transit to prevent the introducing of oriental fruit fly. Based on the information and data provided by Chinese government, the U.S. was

convinced that the oriental fruit fly was not present in Hebei province. But cold treatment was still required for Ya pears from Shandong province.

4. *Information Memo for the Record* (Podleckis and Usnick, 2005). This memo reviews the history of negotiation for export of Fragrant pears into the U.S., generally reviews the 1994, 1997 and 2001 pest risk assessments, and also provides detailed analysis of seventeen pests of concern for Fragrant pears.
5. *Administrative instructions: Conditions governing the entry of Ya variety pears from China* (USDA/APHIS, 2005a). This regulation provides the phytosanitary requirements under which Chinese Ya pears can enter the U.S.
6. *Importation of Fragrant Pears from China* (USDA/APHIS, 2005b). This the final rule of regulating the imports of Chinese Fragrant pears into the U.S.

Regulation for Australia Imports of Chinese Pears and Apples

The Australia government received an application from China in April 1992 seeking market access for Ya pears from Heibei and Shandong provinces and in 1999, Australia finished a final Import Risk Analysis (IRA) on Ya pears from these two provinces. Australia began the import of Chinese Ya pears from Hebei province in 1999 and from Shandong province in October 2000 under the requirements listed in this IRA. In January 2003, Biosecurity Australia completed a review of all existing import conditions for pome fruit imports from North Asia into Australia. Based on this review, Australia removed the requirement for petal testing to detect brown rot and black spot, and flower cluster examination at blossoming for scab on Ya pears from China. In March 2001, during the China-Australia bilateral plant quarantine technical discussion in Beijing, China requested market access for Sand pears from Shandong province. After receiving additional information from AQSIQ and a site visit to Shandong province by pathologists from Biosecurity Australia, the trade of Sand pears from Shandong province was regulated as an extension of existing policy for Ya pears. Therefore, the trade of Sand pears from Shandong province began in October 2003. China requested consideration for export of Sands pears and Ya pears from Shaanxi province, Sand pears from Hebei province, and Fragrant pear from Xinjiang province during the period between March 2001 and May 2004. In late July 2005, a plant pathologist from Biosecurity Australia visited pear production areas in Xinjiang Uighur

Autonomous Region and Shaanxi province. In October 2005, Biosecurity Australia completed the final version of the draft extension for pears from China.

Australia currently permits the import of Ya pears from Hebei and Shandong Provinces, and Asian (Shandong) pears and Sand pears from Shandong Province. Pear exports from China have increased considerably in recent years. The following Australian regulations related to Chinese pears are included as references: 1) *Final Import Risk Analysis of the Importation of Fruit of Ya Pears from the People's Republic of China* (Hebei and Shandong Provinces) (AQIS, 1998); 2) *Import of Asian ('Shandong') pear (Pyrus pyrifolia (Burm.) Nakai and P. ussuriensis var. viridis T. Lee) fruit from Shandong Province in the People's Republic of China* (Biosecurity Australia, 2003); 3) *Draft Extension of Existing Policy for Pears from The People's Republic of China* (Biosecurity Australia, 2005a); 4) *Final Extension of Policy for the Import of Pears from the People's Republic of China* (Biosecurity Australia, 2005b). Pest risk assessments for the import of Ya pears from Shaanxi province, Sand pears from Hebei and Shaanxi province and Fragrant pears from Xinjiang Unghur Autonomous region were still on-going by Biosecurity Australia at the time of our analysis.

Regulation for Canadian Imports of Chinese Apples and Pears

Canada started importing Chinese Ya pears in late 2002 (Table 3.3). After the U.S. banned Chinese Ya pears due to the disease *Alternaria* sp., the Canadian Food Inspection Agency (CFIA) suspended Ya pears and Asia pears imports from Hebei and Shandong provinces of China respectively on January 28 and February 17, 2004 because of the same disease. In early September 2004, a CFIA delegation visited China to exchange scientific information and concluded that the import of Asian pears had a low risk for entry of the disease *Alternaria* sp. and thus removed the suspension. As for Ya pears, AQSIQ developed a Quality Management System (QMS) in September, 2005 which required auditing by CFIA The import of Ya pears from Shandong Province was resumed as part of a one-year trial period beginning December 1, 2005. In March 2006, another audit was conducted. Beginning March 27, 2006, CFIA also lifted the ban on Ya pears from Hebei province for a one-year trial period which ended March 26, 2007. As similar, the trial period for Asian pears from both Hebei and Shandong ends January 15, 2007. Both of the trial periods were successful and the trades continued.

Table 3.3. Summary of the Regulation of Fresh Chinese Apple and Pear Exports to Canada

Variety	Date	Event
Apple (*Malus* spp.)	November 2004	Apples from Shaanxi Province allowed during two-year trial period which ended in October 2006. Apples from Shandong Province allowed during one-year trial period which ended in October 2005
	October 21, 2006	The trial period ends for the importation of fresh apples from Shaanxi Province with imports allowed to continue
	January 17, 2007	Directive D-02-07 adopted to permit apple imports from Shandong and Shaanxi provinces under specified measures
Asian Pear or Nashi Pear (*Pyrus pyrifolia)*	January 28 2004	CFIA banned the importation of Asian pears from Hebei province of China due to *Alternaria* sp.
	February 17 2004	CFIA banned the importation of Asian pears from Shandong province of China due to *Alternaria* sp.
	Early September 2004	CFIA removed the suspension on Asian pears; The importation was approved both from Hebei and Shandong provinces during a trial period which ended January 15, 2007
Fragrant Pear *(Pyrus* sp. nr. *communis)*	2000	The Exportation of Fragrant pears were approved
Ya pears (*Pyrus bretschnei*)	Late 2002	Canada started importing Chinese Ya pears
	January 28 2004	CFIA banned the importation of Ya pears from Hebei province of China due to *Alternaria* sp.
	February 17 2004	CFIA banned the importation of Ya pears from Shandong province of China due to *Alternaria* sp.
	September 2005	CFIA conducted the first audit on the Quality Management System (QMS)
	December 1 2005	The importation of Ya pears from Shandong Province was resumed under a one year trial period which ended December 1, 2006; Ya pears from Hebei province were still prohibited entry into Canada
	March 27 2006	CFIA conducted the second audit and lifted the ban on importation of Ya pears from Hebei province with all the shipments inspected during a one-year trial period which ended March 27, 2007

Source: Authors' compilation.

In November 2004, fresh apples exports from Shaanxi province were approved to enter Canada under a two-year trial period, which ended October 2006. This trial period was considered a success and the imports continued. Apple exports from Shandong province were allowed during a shorter one-year trial period, which successfully ended October 2005 with trade continuing.

Based on the discussion above, two Canadian regulations related to Chinese pear and apple exports are used as references: *The Interim Policy for Plant Protection Import Requirements for Fresh Pears from China* (CFIA, 2007b) and *The Plant Protection Import*

Requirements for Fresh Apples (Malus spp.) from the People's Republic of China (CFIA, 2007a).

Regulation for Argentine Imports of Chinese Fresh Apples

Argentina began importing Chinese fresh apples in November 2004. There is only one protocol governing apple and pear trade between China and Argentina (Table 3.1): *Protocol of phytosanitary requirements for the apple and pear fruits export from China to Argentina between the Secretariat of Agricultural, Livestock, Fisheries and Food of the Argentine Republic and the General Administration of Quality Supervision, Inspection, and Quarantine of the People's Republic of China* (SENASA, 2005) This protocol includes 12 pests of concern for the exportation of Chinese pears and apples and lists thirteen required steps throughout production, storage, packing, and shipment for Chinese apples exported into Argentina.

3.2 Basis for a U.S. Systems Approach for Chinese Fresh Apples

According to International Standards for Phytosanitary Measures No. 14 (FAO/IPPC, 2002), as a pest risk management policy the systems approach should be based on conclusions drawn from a pest risk assessment. One of the most important results of the assessment is a list of pests of concern associated with the traded commodity. Depending on assessment of pest risk and economic consequence, the trading country decides whether or not to undertake pest risk management and the strength of measures to use (FAO/IPPC, 2002). Therefore, a hypothetical list of pests of concern will be drawn which are associated with potential fresh apple trade between the U.S and China through comparison of the reference policies. It is reasonable to include pests that are identified as pests of concern in most of these policies. In addition, some (but not all) polices provide more detailed pest risk assessment results, rating risk for specific pests, most of which are expressed qualitatively in terms of "low," "medium" or "high." In addition, those pests rated "high" by at least one of the reference policies are also included in the list.

After pests of concern are identified, a list of n phytosanitary measures are specified as used in the reference policies for Chinese apples and pears. These n measures are mentioned by at least one of the policies. According to the standard systems approach, these n measures can be divided into four periods: pre-harvest, harvest, post-harvest, and shipping and distribution. A subset m of the n ($n > m$) common measures is required more than once among these policies and is included in our hypothetical systems approach for Chinese fresh apples.

3.3 Potential Pests of Concern

According to the procedure and criteria of pest risk analysis, a long list of quarantine pests is first identified by the importing country in the early stage of the PRA process. The importing country will often request evidence from the exporting country to show that the quarantine pests do not pose risks associated with the traded commodities. Often a delegation from the importing country will visit the exporting country to collect corresponding information. Based on additional information and evidence, a shorter list of pests of concern will be obtained. Table 3.4 is a summary of the number and type of pests of concern identified by policies listed in Table 3.1. Pests can be divided into arthropods and pathogens. Arthropods include acari (mites), coleoptera (beetles, weevils), diptera (flies), hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, and whiteflies), hymenoptera (ants, wasps) and lepidoptera (moths, butterflies). Pathogens normally include fungi and bacteria (Biosecurity Australia, 2005a).

Table 3.5 provides more detailed information about the pests of concern listed in these policies.[26] There are a total of 56 distinct pests mentioned in these five policies. Among these 56 pests, only peach fruit moth is common to all five policies, as shown in summary in Table 3.6. Four pests are common to four of the five policies; and five pests are common to three of the five policies, nine pests common to two policies, and thirty-seven additional pests are mentioned by only one of the five policies.

[26] In addition to the policy documents listed Table 3.1, the "2005 Memo for Fragrant Pears" (Podleckis and Usnick, 2005) is included as a reference for Table 3.5. It shows detailed pests of concern for the import of Chinese Ya, Sand, and Fragrant pears into the U.S., summarizes previous PRA results, and provides the latest pest risk assessment result for Fragrant pears. The export of Sand pears to the U.S. has not been approved yet.

Table 3.4. Summary of Pests Listed in the Reference Policies

Country	Policy	Quarantine Pests and Pests of Concern
U.S.	USDA/APHIS, 1994	64 quarantine pests; 13 evaluated as pests of concern
	Cave and Lightfield, 1997	560 quarantine pests: 280 pests of *Pyrus*, 53 pathogens, 227 arthropods; 13 evaluated as pests of concern
	Podleckis and Usnick, 2005	17 pests of concern
Australia (Pears)	Biosecurity Australia, 2003	40 pests of concern; 32 arthropods, 1 bacteria and 7 fungi
	Biosecurity Australia, 2005b	39 pests of concern; 31 arthropods (1 acari, 5 coleoptera, 1 diptera, 8 hemiptera, 2 hymenoptera and 14 lepidoptera) and 8 pathogens (fungi)
Canada (Pears)	CFIA, 2007b	12 pests of concern
Canada (Apples)	CFIA, 2007b	10 pests of concern (6 insects, 1 mite and 3 fungi)
Argentina (Apples, Pears)	SENASA, 2005	12 pests of concern

Source: Policies and regulations in Table 3.1.

Table 3.5. Comparisons of Pests of Concern from References

Scientific Name	Common Name	U.S. (Pears)	Australia (Pears)	Canada (Pears)	Canada (Apples)	Argentina (Apples and Pears)
Acleris fimbriana	Fruit tree tortrix		✓			
Acrocercops astaurota	Pear bark miner		✓			
Acrobasis pyrivorella	Pear fruit moth		✓			
Adoxophyes orana	Summer fruit tortrix (Fisher)		✓	✓	✓	
Alternaria gaisen(=kikuchiana)	Black spot (Nagano) of Japanese pear	✓	✓	✓		
Alternaria spp.	Causative agent of Chocolate spot of Ya pears		✓	✓		
Amphitetranychus viennensis	Hawthorn spider mite (Zacher)				✓	
Anarsia Lineatella	Peach twig borer					✓
Bactrocero Dorsalis (Hendel)	Oriental fruit fly	✓	✓			✓
Cacopsylla pyrisuga	Pear wood psylla		✓			
Carposina sasakii(=niponensis)	Peach fruit moth (Matsumura)	✓	✓	✓	✓	✓
Ceroplastes Japonicum	Japanese wax scale					✓
Ceroplastes Ruhens	Ruby wax scale					✓
Choristoneura longicellana	Common apple leaf roller		✓			
Conogethes (Dichocrocis) punctiferalis	Yellow peach moth (Guenee)	✓		✓	✓	✓
Cydia funebrana (Treitschke)		✓				
Cydia inopinata (Heinrich)	Manchurian codling moth	✓			✓	✓
Diaporthe tanakae	Twig blight (Kobaryashi& Sakuma)			✓	✓	

Diaspidiotus ostreaformis	Pear Oyster Scale					✓
Dolycoris baccarum	Sloe bug		✓			
Ectomyelosis Pyrivorella	Pear Fruit Moth					✓
Euzophera pyriella	Pyralid moth		✓			
Grapholitha inopinata	Manchurian fruit moth		✓			
Grapholita molesta	Oriental Fruit Moth (Busck)			✓	✓	
Gymnosporangium asiaticum	Japanese pear rust	✓	✓			✓
Gymnosporangium sabinae	European pear rust	✓	✓			
Halyomorpha picus	Yellow-brown stink bug		✓			
Holotrichia parallela	Large black chafer		✓			
Holotrichia titanis	Brown chafer		✓			
Hoplocampa pyricola	Pear sawfly		✓			
Leucoptera malifoliella (=scitella)	Pear leaf blister moth (Costa)	✓	✓	✓	✓	
Lopholeucaspis japonica	Pear white scale		✓			
Lymantria dispar	Gypsy moth		✓			
Monilinia fructigena	Brown rot (Honey)	✓	✓	✓	✓	
Monilinia mali	Apple blossom blight				✓	
Mycosphaerella pomacearum (Cord.) Sacc.	Leaf spot	✓				
Numonia(=Myelois) pirivorella	Pear fruit moth (Matsumura)	✓		✓		
	Pear rustry skin viroid	✓				
Pandemis heparana	Apple brown		✓			

	tortrix					
Phomopsis fukushii	Japanese pear canker		✓			
Physalospora piricola	Physalospora canker		✓			
Pseudococcus comstocki	Comstock's mealybug		✓			
Rhynchites coreanus	Pear leaf weevil/curculio		✓			
Rhynchites foveipennis (Fairm)	Korean pear weevil/curculio	✓	✓			
Rhynchites heros (Roel)	Japanese pear weevil	✓	✓			
Spilonota albicana	Eye spotted bud moth		✓			
Spilonota lechriaspis	Tipshoot tortrix		✓			
Spilonota ocellana	Eye spotted bud moth		✓			
Sphanostigma iakusuiense	Powdery pear aphid		✓			
Stephanitis nashi	Pear lace bug		✓			
Tetranychus kanzawai (Kishida)	Kanzawa spider mite	✓				✓
Tetranychus truncatus	A red spider mite (Ehara)			✓		
Tetranychus viennensis	Hawthorn spider mite (Zacher)	✓	✓	✓		✓
Urochela luteovaria	Pear stink bug		✓			
Vespa mandarinia	Paper wasp		✓			
Venturia nashicola	Japanese pear scab	✓	✓			

Source: Policies and regulations listed in Table 3.1.
Note: The U.S. treats *Gymnosporangium asiaticum and Gymnosporangium sabinae* as the same pests. But they are shown here as two pests. Therefore, there are actually 18 pests of concern in table 3.5 for U.S rather than 17 as mentioned in table 3.4.

Table 3.6. Pests of Concern Selected for U.S. Imports of Chinese Fresh Apples

	Pest (Scientific Name)	Pest (Common Name)	Risk Potential*
Mentioned by all 5 reference policies	*Carposina sasakii(=niponensis)*	Peach Fruit Moth	High
Mentioned by 4 of 5 reference policies	*Conogethes(Dichocrocis) Punctiferalis*	Yellow Peach Moth	High
	Monilinia fructigena	Brown Rot	High
	Leucoptera malifoliella (=scitella)	Pear Leaf Blister Moth	N/A**
	Tetranychus viennensis	Hawthorn Spider Mite	High
Mentioned by 3 of 5 reference polices	*Adoxophyes orana*	Summer Fruit Tortrix (Fis1her)	N/A
	Alternaria gaisen(=kikuchiana)	Black Spot (Nagano) of Japanese Pear	High
	Bactrocero Dorsalis (Hendel)	Oriental Fruit Fly	High
	Cydia inopinata (Heinrich)	Manchurian Codling Moth	High
	Gymnosporangium asiaticum	Japanese Pear Rust	N/A
Other pests rated as “high” by at least one of the reference policies	*Cydia funebrana (Treitschke)*		High
	Rhynchites foveipennis (Fairm)	Korean Pear Weevil/Curculio	High
	Rhynchites heros (Roel)	Japanese Pear Weevil	High
	Tetranychus kanzawai (Kishida)		High

Source: Author’s determination (Gao, 2007) from reference policies (see text for discussion)
Notes: * The pest risk potential is from the U.S. 1997 Decision sheet (Cave and Lightfield, 1997), which was the supplemental pest risk assessment for Chinese Ya and Fragrant pears. Thirteen pests were evaluated in the pest risk assessment and eleven of them were listed in this table 3.5. The other two pests (and assessed risk levels) were *Numonia pirivorella* (Medium) and Pear rusty Skin viroid (medium).
** N/A means the pest rating is not mentioned by any of our reference policies.

Some (but not all) of the policies also provide more detailed pest risk results. The U.S. policies (Cave and Lightfield, 1997 and Podleckis and Usnick, 2005) and Australian policies (AQIS, 1998 and Biosecurity Australia, 2005b) provide qualitative pest risk ratings in terms low, medium or high risk. In U.S. 1997 decision sheet, the pest risk rating is a combination of the consequences and likelihood of introductions.[27] Each of these factors is evaluated in terms of low, medium or high and then a final pest risk potential is obtained. Among thirteen pests of concern listed in the 1997 decision sheet, eleven pests were rated as “high’ and two were rated as “medium” (Cave and Lightfield, 1997). Similar to the U.S. pest risk assessment, in the final extension of policy for Chinese pears by Australia (Biosecurity Australia, 2005b), the unrestricted risk is a combination of the probability of entry (import, distribution), establishment and spread, and the consequence. This 2005 Australian policy provides a list of thirty-nine pest of concern, but only provides detailed pest risk rating for three pests (Japanese pear weevil, chocolate sport of Ya Li pear and European pear rust) with risk rating of “very low,” “very low” and “low,” respectively.

Among the fourteen pests/diseases in table 3.6, several merit further analysis. All five reference polices mentioned peach fruit moth and it is rated as high risk by USDA. Brown rot is the only fungi (pathogen) among the pest mentioned by four policies and it is also rated as high risk. Hawthorn spider mite is the only Acari (mite) among the pests mentioned by four policies. These pests are depicted in Figure 3.1 and their characteristics are summarized in Table 3.7.

<u>Peach Fruit Moth</u>

Peach fruit moth (*Carposina sasaki or niponensis)* is mentioned by all five reference polices and rated by USDA as high risk. Hosts are apples, peaches and pears, apricots, hawthorns, plums, quinces and *Ziziphus mauritiana*.[28] The moths are mainly distributed in Asia (China, Korea and Japan) and North America (Canada). The larvae tunnel all parts of fruit, feeding on the fleshy parts and on the seeds. Several larvae may feed on each fruit. Larvae can survive for long periods in stored fruits, so imported fruits are the most likely means of entry (EPPO/CABI, 1996). USDA inspectors find the moth almost every year on raw fruit from Japan and Korea. Peach fruit moth may cause heavy losses if it is not under control. International dispersal by flight is extremely unlikely since the moth normally flies only short distance (Sun, et al., 1987). In Europe, the introduction of peach fruit moth could have a severe economic impact

[27] The consequences of introduction, also the economic importance, is evaluated again climate, host, host range, dispersal, economic and environmental factors. The likelihood of introduction is rated relative to the combination of the likelihood of surviving postharvest treatment, likelihood of suviving shipment, likelihood of not being detected at port of entry, likelihood of moving to suitable habitat, and likelihood of finding suitable hosts. More detail information about methodology and rating criteria can be found in “Guidelines for Pathway-Initiated Pest Risk Assessments” (USDA, 2000).

[28] *Ziziphus mauritiana* is a tropical fruit tree species and its common name is Chinese apple or Indian jujube.

on the fruit-growing areas (EPPO/CABI, 1996). In China, the infestation rate ranges from 10 percent to 30 percent in middle of Yellow River old riverway and Northwest Yellow Plateau area. In Bohai bay apple production area, which has relatively higher management technology, the infestation rate is as low as three percent. According to the datasheet on quarantine pests from the European and Mediterranean Plant Protection Organization (EPPO), Hwang (1958) estimated one-third production losses of the apple crop in Liaoning province. Sytenko (1960), Pavlova (1970), and Gibanov and Sanin (1971) estimated 40 to 100 percent damage for apples in Russia. Sun, *et al.* (1987) states that the moth can be controlled by applying fenitrothion, parathion, fenvalerate or deltamethrin at the oviposition peaks of the first and second generations, in combination with the mechanical removal of fallen fruit (EPPO/CABI, 1996). To control the moth, Yoichi and Shirai (2004) claim that a period of cold storage two month before export is sufficient for the apples from Japan, but harvesting in an earlier season or a shorter period of cold treatment may increase the risk of accidentally shipping apples that contain live larvae. USDA/APHIS requires that apples from both Japan and the Republic of Korea must be cold treated and then fumigated for the peach fruit moth (USDA/APHIS, 2007b).

Figure 3.1: Peach fruit moth (left), Brown rot (middle) and Hawthorn spider mite (right) on apples

Source: Peach fruit moth: http://www.invasive.org; Brown rot: http://www.dkimages.com; Hawthorn spider mite: http://www.inspection.gc.ca.

Table 3.7. Summary of Characteristics of Three Quarantine Pests

Pest name	Category	Contents
Peach fruit moth *(Carposina sasakii(=nipon ensis)*	Hosts	Apples, peaches, pears; Apricots, hawthorn., plums, quinces and *Ziziphus mauritiana* are also noted as hosts
	Geographic Distribution	Asia (Northeast part of China, Korea Democratic People's Republic, Korea Republic, Russia) and North America (Shutova, 1970); China: Fujian, Guangdong, Hebei, Heilongjiang, Henan, Jiangsu, Jilin, Liaoning, Shaanxi, Ningxia, Shandong and Zhejiang provinces (Podleckis and Usnick, 2005)
	Detection and Identification	The larvae tunnel all parts of the fruit, feeding on the fleshy parts and on the seeds. Several larvae may feed in each fruit. Infested apples exude a sticky gum, pears turn yellow and apricots ripen unevenly
	Mitigation measures	Fenitrothion, parathion, fenvalerate or deltamethrin (Huan, *et al.*, 1987); cold storage during shipment (Ishiguri and Shirai, 2004); Fumigation: 23g/m^3 methyl bromide for 4 h at > 15^0C for overwinter caterpillars, with slightly lower doses (17-20 g/ m^3) for caterpillars of the summer generation (EPPO/CABI, 1996)
	Production loss	One third of production loss in China (Hwang, 1958); 40%-100% damage for apples in Russia (Sytenko, 1960; Pavlova, 1970; Gibanov and Sanin, 1971)
Brown Rot (*Monilinia fructigena* Honey**)**	Hosts	Apples, pears, plums, peach, nectarine, apricot, quince and cherries (Mackie, *et al.*, 2000)
	Geographic Distribution	Widely spread in Europe; the former Soviet Union; the middle and far east, India and north Africa; U.S: Florida and Maryland (Mackie, *et al.*, 2000); China: Gansu, Hebei, Heilongjiang, Henan, Jiangsu, Liaoning, Ningxia, Shandong, Shanxi, Sichuan, Taiwan, Yunnan, and Zhejiang provinces (Podleckis and Usnick, 2005)
	Detection and Identification	Brown rot develops rapidly through wounds on apples at nonrefrigerated temperatures. Enlarged rots are soft but not mushy (Pierson, *et al.*, 1971)
	Mitigation measures	Prompt cold storage after harvest (Pierson, *et al.*, 1971)
	Production loss	
	Total	Fruit losses: 5%-35% in general (Mackie, *et al.*, 2000); 9% of apple fruits become infected with brown rot (Leeuwen, *et al.*, 2000)
	Pre-harvest	Yield loss not exceed 5% in the pre-harvest stage in 1997 and 1998; Pre-harvest yield loss on average 27.2% in 2001 and 41.6 in 2002 by fruit harvest (Holb, 2004)
	Post-harvest	Mean post harvest losses: 0.1%-0.6% between 1982 and 1988 (Berrie, 1989)

Hawthorn Spider Mite *(Tetranychus viennensis)*	Hosts	Fruit trees of the family Rosaceae, like hawthorn, quince, apple, blackthorn, cherry, peach, plum, apricot, pear, flowering quince, raspberry and mountain ash (Li, *et al.*, 2006)
	Geographic Distribution	England, France, Germany, Austria, Bulgaria, Northern India, Korea, Japan and China (Afonin, *et al*., 2006); China: Anhui, Gansu, Henan, Jiangsu, Liaoning, Ningxia, Shandong, and Xinjiang provinces (Podleckis and Usnick, 2005)
	Detection and Identification	Feeds mainly on leaves and on flowers of fruit trees. It also feeds on the surface of developing fruits and may foul them with its webbing
	Mitigation measures	Biological control agents; acaricide treatment in spring after mass appearance of the mites with an average air temperature of 10°C
	Production loss	Yield of apples is reduced by 30%-50% (Wang, *et al*., 2006); Yield of plum is reduced 2-3 times (Afonin, *et al*., 2006)

Source: Authors' analysis from reference sources (Gao, 2007)

<u>Brown rot</u>

Brown rot *(Monilinia fructigena)* is mentioned by four of five reference polices and rated as high risk by USDA. This species is one of three *Monilinia* fungal species responsible for brown rot, although it is a minor disease of apples and other pome fruits compared with other diseases. The main hosts are apples, pears, plums, and cherries. Brown rot exists and has been identified in most parts of Europe, the former Soviet Union, the middle and far east, India and North Africa, parts of the U.S. and some provinces in China. If a ripe fruit is infested, the first symptoms are small, superficial, circular brown spots that quickly turn to rotting and then the entire fruit is decayed. Diseased fruit tend to remain attached to the tree. Mummified fruit hang on branches of trees until spring or, alternatively fall to the ground where they remain throughout the winter months, partly or completely buried beneath the soil or leaf litter. Brown rot on ripening or mature fruit typically develops as a rapidly spreading, firm, brown decay. The spore can be transported by wind, rain, or insects to young fruit. Infection can take places at any stage during fruit development but only in those fruits approaching the ripening stage is the disease more severe (Podleckis and Usnick, 2005).

Brown rot can cause considerable economic losses worldwide. In Europe, brown rot causes serious losses of apples, pears and plums, particularly in hot summers. In general, fruit losses resulting from infection can range from 5 up to 35 percent (Mackie, 2000). During the pre-harvest period, Holb (2004) estimated average yield losses from the fungi of 27.2 percent in

2001 and 41.6 percent in 2002. During the post-harvest period, Berrie (1989) estimated the mean losses in cultivar Cox's Orange Pippin ranged from 0.1 percent to 0.6 percent during the period 1982-1988.[29] Literature reports that an average of about nine percent of apple fruit become infected with brown rot in a study over three consecutive seasons (Leeuwen, *et al*., 2000). Brown rot is controlled through low temperatures, more readily in incipient and very early stages than after the disease becomes well established in the fruits. Practical control after harvest can be accomplished by prompt storage and rapid cooling to the desired temperature (Pierson, *et al.*, 1971).

<u>Hawthorn Spider Mite</u>

Hawthorn spider mite (*Tetranychus viennensis*) is mentioned by four reference polices. It was reliably identified by Batra in a single collection from Maryland in 1979. The main hosts are fruit trees of the family Rosaceae, like hawthorn, quince, apple, blackthorn, cherry, peach, plum, pear, and flowering quince. Hawthorn spider mite is found mainly on the leaves and stems of host plants, especially during the flowering, seeding, and vegetative growing stages (Podleckis and Usnick, 2005). Its spread is mainly in Europe and Asia, including Japan and China. Injured leaves turn yellow with the underside colonized by mites and covered with webs. The number of males in a populations is 3-5 times less than that of females. In the mid 20th century, excessive use of pesticides stimulated outbreaks of hawthorn spider mite. These were mainly connected to the elimination of entomophages in gardens and to the capability of mites to develop resistance against pesticides. Trunks and branches of fruit trees are densely covered by webs after mass propagation of mites. Strongly infested trees are defoliated and bud formation is decreased the next year. Literature reports that longevity and fecundity of hawthorn spider mite depend on ecological conditions such as temperature and host plants (Kasap, 2003). Climate conditions, especially temperature, are critical abiotic factors influencing the dynamic of the spider mite and their natural enemies. The mite is windborne and may be carried accidently by large insects, birds, and even humans on their clothing (Podleckis and Usnick, 2005). Yield has been reported reduced by 30 to 50 percent (Wang, 2006). Biological control agents can be applied to control

[29] Cox's Orange Pippin is a cultivar of apple, which accounts for over 50% of the UK area of dessert apples (Wikipedia, 2007).

the mite. Acaricide treatment can be used in spring after mass appearance of the mites with an average air temperature of 10°C. Mechanical control in the packing house is also an option.

3.4 Hypothetical Systems Approach Measures

Pest risk assessment conclusions are used to decide whether risk management is required and the strength of measures to be employed (FAO/IPPC, 2004). Pests rated with low risk potential may require only port of entry inspection to maintain phytosanitary security. Pests with medium to high risk potential may require more stringent phytosanitary measures (Cave and Lightfield, 1997). The reference policies provide corresponding phytosanitary requirements for the import of Chinese fresh apples and/or pears. A hypothetical systems approach for Chinese fresh apples is developed based on these policies and the standard form for such approaches developed by USDA/APHIS.[30] Most management operations are applicable to a broad range of pests (AQIS, 1999) so that individual treatment of pests is unnecessary. The mitigation measures included in a systems approach can be broadly classified in four categories: exclusion of a pathogen, detection of a pathogen, elimination of detected pathogen population, or risk reduction of establishment in the importing region. Measures in any of the categories can be applied at four time periods during the agricultural production sequence: pre-harvest, harvest, post-harvest and shipping and distribution (USDA/APHIS/PPQ, 2002). Summary descriptions for each measure mentioned by reference polices are shown in Table 3.8 to Table 3.11.

<u>Phytosanitary Measures in Pre-harvest Period</u>

According to the standard systems approach, pre-harvest measures normally include field certification/management (like treatments, biocontrols); protected conditions (like glasshouses, fruit bagging); resistant or less susceptible cultivars; harvesting plants at certain age or time of year; vector mating disruption; cultural controls, vector- and pathogen-free areas, places or sites of production; low pest prevalence (continuous or at specific times); and testing and subsequent elimination of infected components (USDA/APHIS/PPQ, 2002). Pre-harvest period measures from the reference policies are grouped into the corresponding standard categories in Table 3.8.

[30] The standard systems approach (see the first column of tables 3.8 to 3.11) is from page 15-16 in "Preventing the Introduction of Plant Pathogen into the United States: The Role and Application of the "Systems Approach" (USDA/APHIS/PPQ, 2002).

Typically measures are not needed in every possible category and the reference policy measures fall into the categories field certification/management; protected conditions/cultural controls, vector- and pathogen-free areas, places or sites of production; and testing and subsequent elimination of infected components. The following are the measures that will be included in the hypothetical system approach for Chinese fresh apples.

Table 3.8. Pre-harvest Measures in Systems Approaches for Chinese Apples and Pears

Reference Policies		Common Measures
Field certification/management (treatments, bio-control, etc)		
Argentina (Apples and Pears)	From orchards registered by AQSIQ and designated by both SENASA and AQSIQ; Monitoring for *Baclrocera dorsalis* in the orchard and within a surrounding area of 1 km radius	Fresh apples must be from registered orchard by AQSIQ in the desired export area (Shandong and/or Shaanxi Province)
Australia(Pears)	Pear must be from registered orchards by AQSIQ in the designated export areas; Registered growers must implement an orchard control program; Fruit fly monitoring system--the traps must consist of cue lure, trimedlure and methyl eugenol; a minimum of one methyl eugenol trap should be placed in each export orchard and any village present	
Canada (Apples)	Approved orchards by AQSIQ in Shaanxi and Shandong provinces in China	
Canada (Pears)	Approved orchard by AQSIQ from Hebei, Shandong and Xinjiang provinces in China	
U.S. (Fragrant Pears)	Pears must have been grown in the Korla region of Xinjiang province in a production site that is registered with the national plant protection organization of China (AQSIQ)	
U.S. (Ya Pears)	Approved orchard by AQSIQ in Hebei or Shandong Province	
Protected conditions/cultural controls		
Argentina (Apples and Pears)	The export pear shall be protected by bagging until the packinghouse; The export apple shall be protected by bagging and the bag must not be removed more than 4 weeks prior to harvest	Apples must be bagged without holes on the trees
Australia(Pears)	Bags must be placed over Ya pears, Sand pears and Asian pears grown in Shandong and Shaanxi provinces when the fruit is no more than 2.5 cm in diameter; Bags must be removed in the packing house away from the packing line; No fallen fruit is to be collected for export	
Canada (Apples)	Apples must be bagged without holes just after flowering, provided fungicide application has occurred during flowering and until more than four weeks prior to harvest; Field inspection and/or chemical control for fruit boring moths after the bags have been removed	
Canada (Pears)		
U.S. (Fragrant Pears)		
U.S. (Ya Pears)	Using pesticides; bagging the pears on the trees	

Vector-and pathogen-free areas, places or sites of production		
Argentina (Apples and Pears)	Apples are from area free of *Baclrocera dorsalis* and from free production site for *Gymnsporangium asiaticurn;* With 1 km from the gruit production place, no transiting host tree	Apples must be from pest free areas or production site free of listed pests
Australia(Pears)	AQSIQ must ensure that telial hosts of Japanese pear and European pear rust occurring within 2 km of registered orchards are removed	
Canada (Apples)	In registered orchards, cultural practices, chemical controls and field inspection (or monitoring) programs are carried out to ensure freedom from quarantine pests	
Canada (Pears)		
U.S. (Fragrant Pears)	All propagative material introduced into a registered production site must be certified free of the pests listed	
U.S. (Ya Pears)		
Testing and subsequent elimination of infected component		
Argentina (Apples and Pears)		Field inspection and/or monitoring system
Australia(Pears)	If either Japanese pear rust or European pear rust is found, fruit from the export orchards within 2 km of the infected site will not be accepted into Australia; If brown rot is detected in any designed export area, if the orchards are infected with Japanese pear scab, or if more than 0.5% of fruit are infected with black spot at the time of blossoming, those orchards will be excluded from the export program	
Canada (Apples)		
Canada (Pears)		
U.S. (Fragrant Pears)	Within 30 days prior to harvest, inspect the registered production site for signs of pest infestation and allow USDA/APHIS to monitor the inspections	
U.S. (Ya Pears)	Field inspections for signs of pest infestation by the Chinese Ministry of Agriculture during the growing season.	

Source: Authors' analysis from reference sources (Gao, 2007)

Table 3.9. Harvest Requirements in Systems Approaches for Chinese Apples and Pears

Reference Policies		Common Measures
Culling, inspection or selection		
Argentina (Apples and Pears)	Field inspection or monitoring and/or chemical control for fruit boring moths after the bags have been removed; Apple should be selected, stored and processed to ensure fruit without insects, mites, rotting fruit, leaves, twigs, roots and soil.	
Australia(Pears)		
Canada (Apples)		
Canada (Pears)		
U.S. (Fragrant Pears)		
U.S. (Ya Pears)		
Harvest technique and handling		
Argentina (Apples and Pears)		Bagging the apples/pears through harvest
Australia(Pears)	Bagging the pears (except for Fragrant pear) when the fruit is no more than 2.5 cm in diameter	
Canada (Apples)		
Canada (Pears)		
U.S. (Fragrant Pears)		
U.S. (Ya Pears)	Bagging the pears through the harvest and during their movement to the packinghouse	

Source: Authors' analysis from reference sources (Gao, 2007)

Table 3.10. Post-harvest and Handling Measures (including storage and packing) in Systems Approaches for Chinese Apples and Pears

Reference policies		Common measures
Treatment to kill, sterilize or remove vectors or pathogens (fumigation, irradiation, cold, controlled atmospheres, washing, brushing, waxing, dipping, heat, etc.)		
Argentina (Apples and Pears)	Monitoring for *Baclrocera dorsalis* in the packinghouse; within a surrounding area of 1 km radius.	Post-harvest inspection at certain level or under quarantine supervision by AQSIQ. Cold Treatment;
Australia(Pears)		
Canada (Apples)	Option **b** for un-bagged apples: cold treatment followed by fumigation with methyl bromide.	
Canada (Pears)		
U.S. (Fragrant Pears)	Fragrant pears must be held in a cold storage facility while awaiting export.	
U.S. (Ya Pears)	Cold treatment for *Bactrocera dorsalis*	
Inspection and grading		
Argentina (Apples and Pears)	Packing and storage should be subject to quarantine supervision by AQSIQ.	
Australia(Pears)	Joint inspection for all consignments by CIQ and AQIS; The AQIS sampling protocol requires inspection of 600 units for quarantine pests, in systematically selected samples per homogeneous consignment or lot.	
Canada (Apples)	Post-Harvest Inspection at 5% level and graded.	
Canada (Pears)		
U.S. (Fragrant Pears)	After harvest, inspect the pears for signs of pest infestation and allow USDA/APHIS to monitor the inspections.	
U.S. (Ya Pears)		
Sanitation, including removal of parts of the host		
Argentina (Apples and Pears)	The apples should be stored separately in the chamber to avoid re-infestation.	Fruits must be stored separately in the chamber or carton to avoid re-infestation; Make sure they are not mixed with other fruit or destinations
Australia(Pears)	Pears destined for Australia are not mixed with fruit for other destinations; Culled fruit must be removed from the packing house at the end of each day.	
Canada (Apples)	Safeguard from contamination from orchards or other crops during packing, loading.	
Canada (Pears)		
U.S. (Fragrant Pears)		
U.S. (Ya Pears)		

Certification of packing facilities		
Argentina (Apples and Pears)	From packinghouses registered by AQSIQ and designated by both SENASA and AQSIQ; Packing box should have marking in English indicating the relative production information; the package of apples should be clean the unused.	
Australia(Pears)	All packing houses must be situated within the area subject to a fruit fly monitoring (trapping) program and registered with AQSIQ; Packing houses must be well-lit, and the storage area must be secure to prevent infestation after packing; Pears must be packed into clean, new cardboard or cartons; No fresh or dried packing material of plant origin is to be used; Only processed or synthetic packing material can be used; Fruit must be packed and directly transferred into a shipping container sealed with a AQSIQ seal and not opened until the container reaches its destination; OR, fruit must be packed into cartons with screened ventilation holes; the screening mesh size must not exceed 1.6mm and not less than 0.16 strand thickness; OR fruit must be packed into cartons and the pallet of cartons must be shrink-wrapped in plastic on all six sides.	Each container must be labeled in English and Chinese and marked with the code number of each approved orchard
Canada (Apples)	Apples should be packed and stored in a approved facility only for export to Canada; The facility must be clean and maintained free of pests, soil, plant debris and discarded or infested fruit; Each carton is clearly labeled in Chinese and English or French and marked with the code number of each approved orchard.	Packing houses must be registered from AQSIQ; packing houses must be only used by particular commodity for export.
Canada (Pears)	Clearly labeled in Chinese and English or French; Specify the type of pears and the place of origin; Marked with a number representing the code of each approved orchard; Each carton shall be sealed with a sticker.	
U.S. (Fragrant Pears)	Must be packed in cartons;	
U.S. (Ya Pears)	Packing houses are only used for Ya pears in intact bags and in sealed containers from registered growers.	
Testing with subsequent elimination of infected component		
Argentina (Apples and Pears)	The Phytosanitary Certificate issued by AQSIQ with 2% sampling; AQSIQ provide the sample of Phytosanitary Certificate in advance to SENASA.	A Phytosanitary Certificate issued by either the Shandong or Shaanxi Entry-Exit Inspection and Quarantine Bureau within 14 days prior to shipment and bearing the official stamp of AQSIQ
Australia(Pears)		
Canada (Apples)	Inspection at the 5% level and graded	
Canada (Pears)		
U.S. (Fragrant Pears)	Upon detection of large pear borer, pear curculio or Japanese apple curculio, USDA/APHIS may reject the lot or consignment.	
U.S. (Ya Pears)		

Source: Authors' analysis from reference sources (Gao, 2007)

Table 3.11. Shipping and Distribution Measures in Systems Approaches for Chinese Apples and Pears

Reference Policies		Common Measures
In-transit or on-arrival treatment or processing		
Argentina (Apples and Pears)	Transportation should be subject to quarantine supervision by AQSIQ; Transportation under commercial cold treatment	Shipment must be subject to quarantine supervision by AQSIQ Shipment must be free of other visible pests and free of soil, sand, leaves and plant debris
Australia(Pears)	The fruit must remain within intact bags and be covered by a tarpaulin if they are shipped through an unmonitored area; On arrival, AQIS will examine the documentation for consignment verification prior to release from quarantine	
Canada (Apples)	The apples must be appropriately stored and transported free of quarantine pests and free of soil, sand, leaves, and plant debris	
Canada (Pears)	Shipment must be free of visible pests and signs and symptoms of pests, soil, leaves and plant debris; Shipment will be subject to inspection and sampling on arrival	
U.S. (Fragrant Pears)	Must be shipped in insect-proof containers; May be imported only under a permit issued by USDA/APHIS	
U.S. (Ya Pears)	Phytosanitary certificate issued by the Chinese Ministry of Agriculture	
Restrictions on end use, distribution and periods, and ports of entry restrictions		
Canada (Apples)	A Permit to Import issued under the plant protection regulations, is required during the trial importation period	A permit to import under the plant protection regulation
Canada (Pears)	A permit to import issued under the plant protection regulations is required for the importation of Asian pears from Shandong and Hebei provinces; Not required for the importation of Fragrant pears from Xinjiang province	
U.S. (Fragrant Pears)	Each shipment of pears must be accompanied by a phytosanitary certificate	

Inspection and/or testing with subsequent elimination/denial of entry		
Argentina (Apples and Pears)	After the arrival, SENASA will verify the documents, the labeling and the corresponding phytosanitary inspection	On arrival, inspection of all shipments, verify the documents, labeling and corresponding phytosanitary inspection
Australia(Pears)	CIQ will issue a Master Phytosanitary Certificate for all pre-export inspected lots; If brown rot, black spot, or scab is intercepted on imported fruit, DAFF reserves the right to implement remedial measures as deemed necessary before trade commences next season.	
Canada (Apples)	A Phytosanitary Certificate issued by either the Shandong or Shaanxi Entry-Exit Inspection and Quarantine Bureau within 14 days prior to shipment and bear the official stamp of AQSIQ; On arrival, inspection of all shipments during the trial importation; inspection of random sample of 5% (further 5% if necessary) of the contents of the inspected shipment	
Canada (Pears)	A phytosanitary certificate issued within 14 days prior to shipment; During trial period, 100% of the pear shipment will be inspected; then a random sample of 5% of the contents of the shipment will be examined	
Sanitation (freedom from contamination of carriers)		
Canada (Apples)	Safeguard from contamination from orchards or other crops during the transportation; Shipments free of other visible pests, signs and symptoms of pests, soil, sand, leaves, and plant debris	
U.S. (Fragrant Pears)	Safeguard from pest infestation during transport	

Source: Authors' analysis from reference sources (Gao, 2007)

Pest Free Areas (or Production Sites)

Three of the reference polices require traded apples or pears be from a pest-free area or pest-free production site. Argentina requires the fruit come from an area free of *Baclrocera dorsalis*, from production site or orchards free from *Gymnosporangium asiaticum* and the transiting host tree shall not grow within 1 km of the fruit production site. Australia requires that AQSIQ must ensure that telial hosts (*Juniperus chinensis*, *J. procumbens*) of Japanese pear rust and European pear rust occurring within 2 km of registered orchards are removed. Canada requires for apples that "cultural practices, chemical controls and field inspection (or monitoring) programs are carried out to ensure freedom from quarantine pests". The U.S. requires that all material introduced into a registered production site must be certified free of the pests listed.

The ISPM No. 4 defines a pest free areas as "an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained" (FAO/IPPC, 1996). Generally speaking, the pest free area could be a entire country, or an uninfected part of a country in which a limited infested area is present, or an uninfected part of a country situated within a generally infested area. The pest free areas mentioned by policies for Chinese apples or pears are of the third type. To be more precise, they can be considered a "pest free place of production" or "pest free production site" instead of "pest free area" according to the definition and distinction given by FAO.[31] However some polices use the term "pest free area" (like Argentina) and some use "pest free production site." In China, the government plays a very important role in establishing the pest free production site and maintaining its status by providing funds for lab setup and technical support.

[31] According to ISPM No. 10 "Requirements for the establishment of pest free places of production and pest free production sites" (FAO/IPPC, 1999), the concept of the pest free place of production is distinct from that of the pest free area. They have the same objective but are implemented in a different way. First, a pest free area is much larger than a place of production. Second, a pest free area may be isolated by a natural barrier while a pest free place of production is isolated by creating a buffer zone in its immediate vicinity. Third, a pest free area is generally maintained over many years without interruption while a pest free place of production may be maintained for only one or a few growing seasons. Forth, a pest free area is managed as a whole while a pest free place of production is managed individually by the producer.

Registration of Export Orchards

Almost all the reference policies require that the Chinese apples or pears be from registered orchards in designated export areas in China. The registration of export orchards ensures that orchards from which pears or apples are sourced can be identified (Biosecurity Australia, 2005b). AQSIQ is the government agency responsible for orchard registration. AQSIA determined the requirements for registration systems already being used by China to export fragrant pears to Canada and other countries (USDA/APHIS, 2005b). Canada publishes the list of orchards for the export of Chinese fresh apples and pears.[32] These lists provide names, address, registration number, and variety of the fruit from each of the registered orchards (also the packinghouses) from approved provinces. Summarizing current policies, the designated areas of export of Chinese fresh pears, including Ya, Sand and Fragrant pears, are mainly from Hebei, Shandong, Shaanxi and Xinjiang provinces. The designated export areas of Chinese apples are mainly from Shandong and Shaanxi provinces.

Bagging of the Fruit

Bagging fruit during the pre-harvest period is another important measure included in four of the reference policies, although how this measure is implemented varies across the policies. Argentina requires the bag must not be removed more than four weeks prior to harvest. Australia requires bagging for Ya pear, Sand pear and Asian pear grown in Hebei, Shandong and Shaanxi provinces when the fruit is no more than 2.5 cm in diameter. Canada requires that the bags must be sealed around apples without holes and must not be removed more than four weeks prior to harvest. The U.S. requires bagging pears (except for fragrant pears) on the trees to reduce the opportunity for pests to attack the fruit during the growing season.[33] Bagging can not only beautify the shape and appearance of the fruit, but also efficiently prevent the fruit from becoming infested with certain pest or disease during production.

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[32] The lists of orchards are available at: http://www.inspection.gc.ca/english/plaveg/protect/dir/orch-chinae.shtml. There are 25 registered orchard and 14 registered packinghouse from Hebei province, 35 registered orchard and 2 registered packinghouse from Shandong province, and 45 registered orchard and 6 registered packinghouse from Xinjiang province. Most of the packinghouse are registered in terms of a specific company.

[33] Bagging is not required by the U.S. and Australia for Fragrant pears from Xinjiang province of China. This is due to the smaller size of the fruit, the physiology of ripening of this species and the climatic conditions and pest status of this area (Biosecurity Australia, 2005b).

Field Inspection and/or Monitorying System

The requirement for monitoring systems or inspection during the pre-harvest period is another important common measure mentioned by most of the policies. Some countries require a monitoring system for certain pests. Argentina requires monitoring for *Baclrocera dorsalis*. Australia requires a pest monitoring system for fruit flies. Canada requires field inspection (or monitoring) and/or chemical control for fruit boring for Chinese apples. The U.S. requires general field inspections for signs of all pests. In addition to monitoring and inspection, Argentina, Australia, and the U.S. (for Fragrant pears) also state that if any pest of concern is detected, AQSIQ should immediately report results. For certain pests, if this happens the infected orchard are excluded from the export program or, if certain serious pests are found, all future exports might be suspended. Agencies AQSIQ, MOA and their local offices will be responsible for general monitoring and regular inspection. More detailed measures about the monitoring of orchards are required by some countries. Argentine policy states that monitoring should occur within a surrounding area of 1 km radius at a density of one trap per square km, with the minimum of traps being 3 if the designated orchard's area is less than 3 square km from June 1 to September 30. Australia requires that "a minimum of one methyl eugenol trap should be placed in each export orchard and any villages present" (Biosecurity Australia, 2005b). A few policies mention the use of "pesticide or fungicide" or "chemical control", which are the most basic pest control methods widely used. The monitoring record and inspection results should be available for import country inspectors.

Other Measures during the Pre-harvest Period

Australia requires "registered growers must implement an orchard control program (like good agricultural program or integrated pest management program for export pears)." Australia also requires "the notification of unusual weather conditions occurrence resulting in brown rot, black spot or scab disease" (Biosecurity Australia, 2005b).

Phytosanitary Measures during Harvest

According to the standard systems approach, measures implemented during harvest period include culling, inspection or selection, stage of ripeness/maturity, timing of harvest, sanitation (like removal of reservoir hosts, "trash") and harvest technique and handling (Table 3.9). Comparing these standard measures, most of the reference policies do not specify the stage of ripeness or timing of harvest. Australia and the U.S. (for Ya pears) require continued bagging during harvest period. Argentina requires field inspection and that "apples should be selected to ensure fruit without insects, mites, rotting fruit, leaves, twigs, roots and soil." Therefore, the measure "bagging the apples" during the harvest period are included in the hypothetical systems approach. In addition, inspections should be undertaken to ensure that the apples are harvested without infection from pests of concern.

Phytosanitary Measures in the Post-harvest Period (including storage and packing)

According to the standard systems approach, post-harvest measures include treatment to kill, sterilize or remove vectors or pathogens (fumigation, irradiation, cold, controlled atmosphere, washing, brushing, waxing, dipping, heat, etc.); inspection and grading; sanitation including removal of parts of the host; certification of packing facilities; and testing with subsequent elimination of infected component (Table 3.10). After comparing the measures in the reference policies, the following measures are included in the hypothetical systems approach.

Registration of Packinghouses

Similar to registration of export orchards, almost all policies require registration of packinghouses. In addition, Australia requires the registered packinghouse be maintained in a condition that would provide security against infestation. Packinghouses also need to keep records that facilitate auditing by AQSIQ during grading, packing and storage.

Post-harvest Inspection and Monitoring

Like pre-harvest monitoring requirements, almost all the policies require post-harvest inspection or monitoring measures. Argentina requires that apples and pears be selected, sorted and processed to insure fruits are without insects, mites, rotting fruit, leaves, twigs, roots and soil. The packing and storage is subject to quarantine supervision by AQSIQ. Australia requires pre-clearance phytosanitary inspection and remedial action. Canada requires the apples must be subject to any post-harvest measures deemed appropriate to eliminate pests and free of quarantine pests, oil, sand, leaves, and plant debris. The U.S. requires the inspection for fragrant pears and allows USDA/APHIS to monitor the inspections.

Cold Treatment

Argentina requires commercial cold treatment. Australia requires pears be stored under quarantine security and segregated by at least one meter from all other fruit in a cold storage maintained at 34-37°F (1-3°C) until loaded into containers. The U.S. removed cold treatment for Chinese Ya pears from Hebei province based on sufficient information to show that the oriental fruit fly does not exist there. However, cold treatment is still required for pears from Shandong Province. Since Shandong and Shaanxi provinces are the most likely export areas for Chinese fresh apples, it is necessary to include "cold treatment" as one of the measures in a hypothetical systems approach since there is no official evidence to date to show that there is no oriental fruit fly exiting in these two regions. Cold treatment is generally used by larger exporters in Shandong Province.

Packing and Labelling Requirements

Storage, packing and processing are generally required to be isolated from fruit targeted to other destination. Some policies include specific requirements for packing materials. The fruit should be packed in clean, new cardboard boxes or cartons. Label requirement made by some policies, like Argentina and Australia, generally include marking in certain languages, indication of production place (provinces), orchard or its registered number, and packinghouse or its registered number. These labeling requirements are designed to facilitate trace-back identification in the event of non-compliance (Biosecurity Australia, 2005b).

Phytosanitary Certificate

A phytosanitary certificate is required by most of the countries. Argentina requires the phytosanitary certificate be issued by AQSIQ with a sample provided in advance to SENASA for confirmation. Australia requires CIQ issue a Master Phytosanitary Certificate for all pre-export inspected lots.[34] Canada requires the phytosanitary certificate (include English or French) for apples and pears issued within 14 days prior to shipment and bearing the official stamp of AQSIQ. The requirement for phytosanitary measure is consistent with FAO's ISPM No. 7 Export Certification system (FAO/IPPC, 1997).

Other Specific Requirement for Storage and Packing

Australia requires the fruit must be packed into cartons with screened ventilation holes. The screening mesh size must not exceed 1.6 mm with not less than 0.16 mm strand thickness. Or, the pallet of cartons must be shrink-wrapped in plastic on all six sides. Canada requires the fumigation for apples. These measures are specific to individual countries and thus are not included in the hypothetical systems approach from fresh apple shipments to the U.S.

Phytosanitary Measures in Shipping and Distribution

According to the standard systems approach, the measures in shipping and distribution period include in-transit or on-arrival treatment or processing; restrictions on end use, distribution and periods, and ports of entry restrictions; post entry quarantine, inspection and/or testing with subsequence elimination/denial of entry; and speed and type of transport, and sanitation (freedom from contamination of carriers) (Table 3.11).

Regulatory Inspections by the Importing Country

Argentina states that SENASA will send two quarantine experts to China to conduct an on-site visit prior to program initiation in cooperation with AQSIQ. The experts will review the phytosanitary conditions of production areas, the orchards, packinghouse, storage facility and the system of monitoring for *Baclrocera dorsalis*. AQSIQ is in charge of the invitation, agenda and pays for all the expenses. Australia also states in the policy that AQIS inspectors will visit China each year for pre-clearance inspection, both in the field and packing house, unless otherwise agreed by DAFF and AQSIQ on a region by region basis.[35] The U.S. sent USDA/APHIS delegations to Heibei and Xinjiang province in China several times to collect pest risk evidence for Ya and Fragrant pears in the 1990s and early 2000s, as described above. Therefore, for the

[34] CIQ refers to Entry-Exit Inspection and Quarantine Bureau of the People's Republic of China, which is one department belonging to AQSIQ.
[35] DAFF refers to Australian Government Department of Agriculture, Fisheries and Forestry.

hypothetical systems approach, it is reasonable to include this requirement.

Quarantine Supervision of Shipment

During the shipping and distribution period, most of the policies state the shipment should be under supervision of AQSIQ, and shipment should be guaranteed free of quarantine pests. The U.S. requires the fragrant pears should be shipped in insect-proof containers and all pears must be safeguarded during transport to the U.S. in a manner that will prevent pest infestation.

Import Permit

The U.S. requires the Fragrant pears may be imported only under a permit issued by USDA/APHIS while Canada states that "a permit to import is not required" for Chinese apples or pears. However, the U.S. requires written permits for imported fresh fruits from all foreign sources.[36] Only approved plant part(s) of the fresh fruits are authorized entry. To be consistent with this U.S. requirement, we keep this requirement for import permit in the hypothetical systems approach for Chinese fresh apples.

On-arrival Inspection

Argentina states "when fruit arrives at the entry port, SENASA will verify the documents, the labeling and will do the corresponding phytosanitary inspection." Australia states that AQIS will examine documents for consignment verification prior to release from quarantine and AQIS may open the containers to verify the contents. Canada required 100 percent of pear shipments to be inspection during trial period. When a shipment is inspected, a random sample of 5 percent of the contexts will be examined and a further 5 percent sample may be randomly selected and examined if there is presence of frass.[37] In general, after the on-arrival inspection, most policies state that if the documentation is incomplete, or the seals of the container or labeling have been damaged, or the certification does not conform to specifications, the shipment will be held pending clarification or might be partially re-exported or destroyed.

[36] USDA requires written permits for imported fresh and frozen fruits and vegetables (including fresh herbs and sprouts) for consumption from all foreign sources as well as Guam, Palau, the Federated States of Micronesia, or from the Commonwealth of the Northern Mariana Islands. Refer to the Fruit and Vegetable Import Manual for more detail (USDA/APHIS/PPQ, 2004).

[37] Frass refers to Debris or excrement produced by insects.

3.5 A Hypothetical U.S. Systems Approach for Chinese Fresh Apples

Based on the discussion above, we characterize a hypothetical systems approach for Chinese fresh apple exports to the U.S. (Table 3.12). To summarize, by evaluating current like-product existing policies including corresponding pest risk assessment reports, we first obtained a list of pests of concern associated with potential U.S.-China fresh apple trade. Ten pests are mentioned most frequently by the reference policies and eleven pests have been evaluated by the U.S. as having “high” risk rating.

Seventeen phytosanitary measures were identified for a hypothetical systems approach. As already noted, these measures, as mentioned by the reference policies, include common and general measures in existing regulations. In accordance with the standard systems approach defined by USDA, we divided these measure into four periods: pre-harvest, harvest, post-harvest (including storage and packing), and shipment and distribution. In total, five required measures are included in the pre-harvest period, one measure in the harvest period, six measures in the post-harvest period, and five measures in shipping and distribution. These measures are either those that are mentioned by most of these policies in the references or those mentioned by a few policies but required by the U.S. either for Chinese pears or for all foreign fruits. Even though these measures are described somewhat differently in the various reference policies, they can generally be categorized as defined by the standard systems approach. The seventeen selected steps represent the initial requirements of the policy. In addition, there are two measure which are those mentioned by only one or two reference policies. These are viewed as optional steps that may be considered as part of the hypothetical system approach.

Table 3.12. Hypothetical Systems Approach for U.S. Imports of Chinese Fresh Apples

Period	Phytosanitary Measures for Chinese Fresh Apples
Pre-harvest	Fresh apples must be from registered orchard by AQSIQ in the desired export area (Shandong and Shaanxi Province)
	Apples must be bagged without holes on the trees
	Apples must be from pest free areas or production site free of listed pests
	Field inspection and/or monitoring system must be utilized
	Chemical Control
Harvest	Bagging the apples through harvest
Optional	Field inspection and monitoring
Post-Harvest	Post-harvest inspection at certain level or under quarantine supervision by AQSIQ
	Cold treatment
	Apples must be stored separately in the chamber or carton to avoid re-infestation; Segregation to make sure they are not mixed with other fruit or destinations
	Each container must be labeled in English and Chinese and marked with the code number of each approved orchard
	Packinghouses must be registered by AQSIQ; These packinghouses must be only be used for exported fresh apples when packing fore the U.S.
	A Phytosanitary Certificate issued by either the Shandong or Shaanxi Entry-Exit Inspection and Quarantine Bureau within 14 days prior to shipment and bearing the official stamp of AQSIQ
Optional	Fumigation with methyl bromide
Shipping and Distribution	Shipment must be subject to quarantine supervision by AQSIQ
	Shipment must be free of other visible pests and free of soil, sand, leaves and plant debris
	A permit to import under plant protection regulations is required for the import of Chinese fresh apples
	On arrival, inspection of all shipments, verify the documents, labeling and corresponding phytosanitary inspection
	USDA/APHIS delegations will visit China to review the phytosanitary conditions of productions at certain time of a year or as invited by AQSIQ

4. Field Interviews Concerning Chinese Apple Exports

To gain some additional insights about the issues related to China's apple exports field research was undertaken in Beijing and Shandong Province in June 2006 and July 2007. This research included interviews with managers and owners of apple packing and exporting operations, representatives of several importing-country governments, university analysts, and the professional staff of government operational and research organizations at the national, provincial and local levels. The research also included collection of related written materials that would have been difficult to access without direct in-the-field contacts.

Interviews were conducted in two periods: an initial investigation by Dr. Fuzhi Cheng during June 19-30, 2006 and a follow-up investigation by Dr. Cheng and Dr. David Orden during July 5-20, 2007. During the first and second investigation, interviews were conducted in Beijing, Jinan City, the capital of Shandong Province, and Longkou City. Longkou is a port, county-level city (belonging to prefecture-level city Yantai) located in northeastern Shandong Province on the coast of the Bohai Sea, about 1,000 miles northwest of Shanghai. It is in the heart of the apple producing region and a focal point for fruit and vegetable packing and processing both for China's domestic and export markets.

The primary objective of the first round of interviews was to elicit general information on foreign trade technical measures that have affected China's agricultural exports in recent years. The interviews focused on different cases which were potentially inconsistent with the WTO's SPS Agreement and those for which strategies can be developed to expand export opportunities. To do so, we surveyed opinions of government staffs, researchers, and employees and owners of agricultural trading firms on the current SPS issues, especially those related to foreign food safety regulations that affected exports of major product categories such as fruit and vegetables and products of animal origin.[38]

The issues we sought to investigate in the second-round field interviews were particularly related to apples. They included 1) the history of the negotiations of apple and pear export protocols with Canada and other countries; 2) perceptions by industry stakeholders and government authorities concerning their obligations under the current requirements for exporting; 3) costs of production and processing of fresh apples; 4) technological innovations

[38] See Cheng and Tang (2006) for further discussion.

related to development of the export industry and profusion of these innovations among apple producers and processors; 5) perceptions of the costs associated with exporting versus selling in domestic markets; and 6) perceptions of the relationships between the domestic market and various export markets in terms of phytosanitary requirements, quality standards, and market prices and opportunities. We recognized that the interview process with representatives of specific processing firms, government agencies and others was unlikely to result in precise numerical quantification in terms of such issues as the costs of meeting phytosanitary requirements or export quality standards. However, we anticipated gaining substantial intuition and understanding of the perceptions of these requirements, characteristics and costs among participants in the industry. Enumeration of these insights in this section of the report contributes to understanding the complex ebb and flow of views and decisions associated with the regulatory processes and their implementation when phytosanitary issues arise from trade of agricultural products.

During the two field investigations a total of 30 interviews were conducted with roughly 40 participants (see Appendix II for a complete itinerary and list of interviews during each period). Most of the interviews were conducted primarily in Chinese, Dr. Cheng's native language. Often the written materials collected were also available only in Chinese.

Eleven interviews were undertaken during the June 2006 investigation. These included interviews in Beijing with officials at the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), China Entry/Exit Inspection and Quarantine Bureau (CIQ) of Beijing, and Ministry of Agriculture (MOA); researchers and analysts at the Chinese Academy of Agricultural Economics (CAAS) and the Beijing WTO Information Center. Interviews conducted in Shandong Province included those with officials of MOA and CIQ at provincial and city levels as well as business operators and owners of two major fruit and vegetable exporting firms in Longkou City.

An additional 19 interviews were conducted during July 2007. Included in Beijing were five interviews with embassy representatives (Australia, Canada, the United States, and Argentina).[39] Interviews were undertaken with research economists at the Ministry of Agriculture, Research Center for Rural Economy (RCRE); through presentation of a seminar on

[39] The interview with the representative of Argentina was conducted by Dr. Suzanne Thornsbury and Ms. Lili Gao, Michigan State University.

technical agricultural trade barriers at the Chinese Academy of Agricultural Economics (CAAS) and subsequent discussions with selected faculty; discussions with faculty of the School of Agricultural Economics and Rural Development, Renmin University; and an interview of two representatives of AQSIQ.[40,41] In Shandong Province, interviews were conducted with representative of five apple packing and processing firms, including two that are the only plants in the province registered to export fresh apples to Canada, and two that export fresh apples to other markets. Interviews were also conducted with representatives of the Ministry of Agriculture in Jinan and Longkou, and with a representative of local CIQ responsible for the apple export inspection process.

4.1 History of Negotiations

Interviewees confirmed the lengthy process by which the Canadian import protocol was developed. In the words of one longstanding participant, the process was "not very smooth." However this participant and numerous others commented on the general improvement of the quality of Chinese apple production over the past ten years. The industry was viewed as having been "very ingenious" in finding methods to address importers' concerns about pest risks. One example was the adoption in the packing sheds of a compressed air gun to blow a burst of air through the stem and base of each apple to flush out any pests not detected visually. One person handled each apple solely to perform this task. When asked in general what had become harder and what had become easier in undertaking his responsibilities, one orchard manager with eight years of experience responded that standards for exporting and the domestic market had become more demanding, but that as his experience accumulated meeting these standards was becoming easier. More concretely, high standards for exporting was credited with stimulating improvements in management practices, environmental and product testing, use of higher quality fertilizers and pesticides, investments by some firms in the most advanced controlled

[40] The seminar was "Linking Risk and Economic Assessments in the Analysis of Plant Pest Regulations: The Case of U.S. Imports of Mexican Avocados" presented by David Orden at CAAS, July 11, 2007.

[41] The sensitivity of the governments concerning phytosanitary and other SPS regulations affecting trade was reflected in the arrangements for our interviews with representatives of AQSIQ at the national level and CIQ in Shandong province. In each case, the interview was held at a third-party location instead of the regulatory authority offices. The interviews were conducted on an "off-the-record" basis, not representing official views of the regulatory agency. Under these conditions, the regulatory representatives were very gracious and engaged in a substantial dialogue about their regulatory activities and the related issues.

atmosphere cold storage, and the creation of contract farming and modern supply chains (see further discussion below).

When a successful export market is developed for a high-value agricultural product from a developing country it is often the case that persistence in seeking to develop the market by an entrepreneurial firm plays a critical role. In the case of Shandong apple exports to Canada, the lead firm has been Fook Huat Tong Kee Cold Storage Co. Ltd. (FHTK), which until October 2006 was the only firm in Shandong Province to receive this approval. FHTK is a foreign investment company listed on the Singapore stock exchange, with an extensive distribution and marketing network in 40 countries and over 1000 employees worldwide. It aims to be “an Asian dragon in the world fruit market.” The Shandong processing facility was opened in 1993 and encompasses plant breeding, production, storage, processing, packaging and distribution. Its high-tech controlled atmosphere cold storage facilities adopted advanced technology from Europe and allows the company to preserve the freshness of apples and extend their shelf life up to 12 months. Its extensive marketing network has contributed to a strategy of aggressively seeking to open new markets for Chinese apples and pears. The company highlights this initiative in its promotional materials. In the case of the Canadian market, in the interviews the leadership role of this Singapore based company “during the first round” of market development was attributed to “its close business ties with importers in Canada” and also “good infrastructure.”

The interviewees made two general observations about SPS negotiations. First, several respondents pointed out that there was a need for some form of reciprocity in the discussions. In some cases, this was a matter of informal balancing of discussion of barriers of concern to each country in bilateral negotiations. In other cases, reciprocity became formalized in mutual access requests, such as in agreement by China and Australia to consider mutual access for table grapes, apples and cherries, with apples the first export priority for China and table grapes the first priority for Australia. One interviewee summarized that “everything is a trade-off” in negotiating market access related to SPS barriers. A constraint for China in this context is that with agricultural exports relatively small in relation to its total exports, there are times according to one Chinese official when it would not pursue an SPS issue because of other priorities.

Several interviewees also noted that gaining access to highly selective markets could be of value to a firm not only in terms of the direct exporting opportunities it presented but also as a means of signaling the quality of the firm's products to other countries. This "demonstration effect" was cited as being of value even if exports to the specific country were likely to be limited, and in some cases to be part of a firm's strategy for "improving its image."

4.2 Perceptions of Obligations under the Current Requirements for Exporting

The Canadian import protocol places almost all of the supervisory responsibility for ensuring pest-free apples with the Chinese regulatory authorities. The import protocol reflects the shift in Canadian regulatory policies, as discussed earlier, toward firm-level quality management systems with limited regulatory auditing. Several industry participants pointed out the limited explicit role played by Canadian regulators in the protocol for imports from China. One respondent noted that Canada "did not require any specific measures (particularly use of the air gun), but "only that the exported apples were pest free." However, Chinese regulators indicated that they did require the air gun be used in order to approve a firm for exporting to Canada.

A second prerequisite identified by several interviewees for certain export markets was that the packing firm operated its own orchards or contracted with farmers, as opposed to procuring apples from independent producers. There was ambiguity in these expressed perceptions about whether this was a requirement of the importing country, a consideration by Chinese regulators in approval decisions, or simply a characteristic of many of the leading export firms. In any case, this discussion underscored the importance of closely-managed quality control in successful export development. Comparing the interviews with the Canada-exporting firms and non-Canada exporting firms suggests that the former are more likely to have their own production base (e.g., one staff at FHTK emphasized the importance of their own orchard production in meeting Canadian regulations) while the latter are more flexible to choose between own production base and contracting farming or a combination of both.[42]

[42] According to Directive D-02-07, Canada requires apples from China to originate from orchards approved and registered by AQSIQ. These orchards must be given a code number by AQSIQ. This may be the reason why processing firms exporting to Canada tend to have their own orchards. In addition to this, AQSIQ also requires that the processing firms be registered and coded. For a complete list of registered orchards and packinghouses for exporting fresh apples to Canada in 2006 and 2007, see the AQSIQ website at http://www.aqsiq.gov.cn/qyhypd/ncp/dzwjckqymd/zwjcpqymd/cjsggybzcmd/200701/t20070105_23628.htm (see also Appendix III and the CFIA Web site given in section 3). Similar lists are also available from AQSIQ for exports of fruits to other countries: http://www.aqsiq.gov.cn/qyhypd/ncp/dzwjckqymd/zwjcpqymd/cjsggybzcmd/

For example, an interview with the owner of a smaller-scale fruit-exporting firm that supplies Fuji apples to Southeast Asian and European markets indicates the "production base plus contract farming" mode. The company sells apples through the purchasing system of a large global supermarket chain which has strict quality requirements and has its own quality verification system. In order to guarantee quality, the company has its own production base and contracts with a number of rural farmers. The company makes sure that soil, water and air quality meet the importer's standards and sends technicians to help the farmers and supplies all pesticides. The farmers are required to follow guidance of the technicians. In the harvesting season, the company sends technicians to supervise grading. In order to meet the importers' safety standards, the company chooses pesticides of premium quality and since the price of these pesticides is higher than domestic pesticides, apples are purchased at prices somewhat above the regular market price.

There were some apparent misperceptions expressed by interviewees about the commitments of importing countries. In one case, a representative of a firm not exporting to Canada suggested several times that the firm "might apply next year for approval from Canada and the year after for approval from the United States." His remarks about potential firm strategy implied a lack of understanding that a regulation was in place under which specific firms could apply for approval for Canada, whereas the United States does not allow fresh apple imports from China by any firm under existing regulations. In another case, an interviewee questioned whether Canada had opened its entire market, since the volume of exports seemed too small in his perception. This line of reasoning failed to recognize that the Canadian regulation has no provisions that limit access of apples from approved orchards and packers under the specified production, processing and testing protocols, so that market demand would seem to determine the quantity of apples exported, not explicit regulatory constraints.

4.3 Technology and Cost Considerations

<u>Technological Innovations Related to Exports and Profusion of these Innovations</u>

As noted above, high standards for exporting was widely credited with stimulating a number of improvements in apple production and processing. Among the specific changes identified by interview participants were:

Development of the apple bagging procedure, which has become the dominant production method being applied to about 90 percent of the Fuji apples produced in Shandong Province for the export and domestic markets (see also discussion in earlier sections of the report).[43] This procedure has both reduced pest infestations and contributed to a more uniform and higher-quality appearance of the apple harvest.

Higher Levels of Management, including employment of skilled labor in management positions, hiring of quality control managers; introduction of various systematic quality assurance programs such as ISO, HAACP and Eurogap; development of detailed quality assurance operational manuals; and introduction of detailed record-keeping associated with quality assurance.

Investment in advanced technology, particularly controlled atmosphere cold storage that allows improved pest control and longer post-harvest shelf life.

Use of improved fertilizers and pesticides, as required for various export markets but not generally applied in orchards producing only for the domestic market.

Environmental testing related to water and soil quality, again as required by various export markets.

Improved pest risk management with innovations such as orchard trapping and use of an air gun burst to brush mites out of the stem and base of each apple exported to Canada and other foreign markets.

The bagging procedure has been a technological innovation that has proliferated, whereas other requirements for exporting that raise production and processing costs have not permeated as widely through the Shandong apple industry. The most demanding markets, such as the EU, US, Australia and Canada, are viewed as requiring the most advanced technologies in order to penetrate the market. One of these technologies is the controlled atmosphere cold storage as pointed out by a research staff at the Fruit Technology Promotion Station of Longkou. Companies that are equipped with such technologies are thus better positioned in the export markets. For example, FHTK has a total storage capacity of 35,000 tonnes of which 25,000 tonnes are of advanced atmosphere controlled cold storage. The manager of a second firm, Longkou Shengxing Fruit and Vegetable Co. Ltd, which was approved in October 2006 for

[43] Canada requires bagging of apples until no more than four weeks prior to harvest, or cold treatment of unbagged apples at or below 1.1 °C for 40 days, followed by fumigation with methyl bromide according to specific schedules (CFIA, 2007).

exports to Canada, was reluctant to provide estimates of the specific costs he had incurred to gain this approval. Instead he emphasized the merit of making investments in such technology as advanced cold storage that moved his company to the cutting edge of high-quality production, and that this was "more important than the costs incurred."

Costs of Production and Processing of Fresh Apples

Costs of production as estimated and reported by Chinese official statistics and independent observers have been discussed in section 2. Table 4.1 provides a further breakdown of costs of production for Shandong Province and selected others**.** The apple orchards in Shandong Province face the presence of numerous apple pests, as reflected in the pest-control costs in production budgets (included in "material cost" in the table) and confirmed by our informal observations in orchards. In the interviews, we did not obtain additional apple orchard production costs. But interviewees in Shandong Province confirmed that the costs of production were usually higher than other apple producing regions in China because of higher labor costs in this province as a result of its higher living standards and economic development stage. Table 4.1 shows that the labor cost in Shangdong is the highest among all the selected provinces.

Table 4.1. Components of Apple Production Costs by Province in 2004 (per hectare)

Item	Average	Beijing	Tianjin	Hebei	Shanxi	Liaoning	**Shandong**	Henan	Shaanxi	Gansu	Ningxia
Total production value	34,245	27,837	28,287	34,025	23,388	40,797	**63,940**	24,163	31,010	25,523	19,029
Value of main product	34,121	27,837	28,287	33,648	23,388	40,797	**63,845**	23,764	30,801	24,864	19,029
Value of byproduct	124	0	0	377	0	0	**94**	399	209	659	0
Total cost	20,104	17,383	14,919	17,334	17,235	16,930	**36,602**	17,833	21,503	17,963	12,362
Produce cost	18,731	15,215	14,125	16,079	15,614	15,382	**35,391**	17,452	20,266	17,019	11,760
Material cost	9,548	5,999	7,963	8,291	7,599	8,855	**19,982**	6,464	11,016	5,585	4,427
Labor cost	9,183	9,216	6,162	7,788	8,015	6,528	**15,409**	10,988	9,251	11,434	7,333
Family labor cost	7,392	2,390	5,937	6,451	7,014	6,239	**11,790**	10,526	6,675	10,984	6,144
Hired labor cost	1,791	6,826	225	1,337	1,002	289	**3,619**	462	2,576	450	1,189
Land Cost	1,373	2,168	794	1,255	1,620	1,548	**1,212**	381	1,236	944	602
Rent of leased land	87	256	238	63	170	50	**5**	13	53	0	11
Rent for own land	1,286	1,913	556	1,192	1,450	1,498	**1,207**	368	1,183	944	592

Source: China Agriculture Yearbook, 2005

The practice of bagging (and pre-harvest unbagging) adds directly to the cost of production in the orchards. Estimated labor costs related to bagging and unbagging were around 3-4 Chinese cents per bag (1.5-2.0 cents/bag for bagging and unbagging, respectively) in the Longkou area. If the cost of bags is 8 cents/bag, the direct cost related to bagging including the labor cost is 11-12 cents/apple or about 50 cents/kg. One interviewee roughly estimated the total cost of bagging per mu to be approximately 1,000 yuan assuming an average yield of 2,000 kg/mu.

In the interviews we inquired about the relative costs on average of orchard production, processing and storage as percentages of the total cost of marketed apples. Estimates we received placed the orchard costs at about half of the total, packing at about 25 percent and cold storage about 25 percent.

Perceptions of the Costs Associated with Exporting versus Selling in Domestic Markets

Several interview respondents gave their perceptions of the additional costs associated with exporting versus selling in the domestic market. The increment of costs originates both from the orchard stage and processing stage. In order to meet high exporting standards, orchards need to increase the quality of soil, water, fertilizer, pesticide and surrounding environment while packing firms need to be equipped with pest control facilities, including cold storage, and add extra personnel for quality control. A common general observation was that specific requirements for various export markets differed so that it was difficult to give a general answer about export practices or their specific costs. Interviewees also emphasized that it was difficult to separate costs associated generally with improving quality of the exported apples from those associated directly with meeting requirements related to pest management. Bagging was one such cost that both reduced pest infestations and improved appearance.

Estimates by interviewees placed the additional costs of exporting compared to producing for the domestic market in the range of 10-30 percent. One interviewee estimated that the costs were about 10 percent higher for the South Asian markets and about 20 percent higher for the EU and Canada. Two other estimates were of added costs of 25-30 percent. The distribution of these costs between orchard operations and packing and storage depended on whether or not the firm had invested in advanced cold storage as part of its export strategy. The operator of one firm that had not made the storage investment suggested that most of the increase in his costs was in the orchard operation (more than 30 percent increase in orchard costs versus less than 20 percent increase in packing and storage). A firm that had made the cold storage investments attributed its cost increase "mostly to the storage activity."

The cost comparisons are for producing apples for possible export versus producing only for the domestic market. As one interviewee pointed out, once the decision is made to produce for possible export, the production process and costs incurred are the same for those apples eventually sold domestically as for those that are exported. In general, estimates of the percentage of apples from a given orchard that mature to "export quality" ranged from 50 percent to 70 percent. Other apples from the orchard would not meet this standard for a variety of reasons such as shape or bruising. Thus, the additional costs have to be recouped from those apples that are exported, although several interviewees noted a growing domestic market for the apples of this premium quality.

Within these overall cost estimates, there is evidence that costs of internal and regulatory pest inspections, as opposed to other quality-related aspects of producing apples for export, are relatively small. No fruit is destroyed in the orchard or packing-house testing process. Additional orchard pest sanitation measures, such as removal of debris and fallen fruit as required by some importing countries, were estimated to add only 1-2 percent to orchard production costs. The interviewee from the Longkou CIQ indicated that the agency charges only a very small fee for each inspection (0.12 percent of total value of shipment).[44] Similarly, inspection fee at the Canadian port is also low (interviewee at the Canadian embassy mentioned the fee was about CA$15 per load).[45] In contrast, use of higher quality bags for exports can add significantly to costs. One interviewee commented that the price of bags they paid for exported apples (8 Chinese cents/bag) was 60 percent higher than those used for domestic sales (5 cents/bag).[46] In addition, the increase of the costs they have incurred for higher quality fertilizer and pesticides and better irrigation systems was about 20-30 percent.

The careful internal inspections during packing also have a cost. For export, each apple is handled by three or four processors (four for Canada for which one operates the air gun to blow

[44] A complete list of CIQ inspection fees is available at http://www.btciq.gov.cn/upload/4036.doc
[45] A complete fee schedule is available at: http://www.inspection.gc.ca/english/reg/cfiaacia/feesfrais/part_6e.shtml
[46] Imported double-layered paper bags from Japan, Taiwan and South Korea can cost up to 15-20 Chinese cents/bag according to one interviewee. However, the wide use of domestic produced paper bags and plastic bags in recent years significantly lowers the cost of bags.

pests off of each apple). For domestic marketing, two handlers would be sufficient. Thus labor costs are increased by 50 percent to 100 percent for the firm's inspections as part of the packing production line, but this activity only account for about five percent of the total labor used in the full packing operation of sorting, inspecting, and packing into boxes. In addition, post-packing internal inspections are undertaken. In one plant we observed packing apples for Canada, the internal inspection involved two employees who inspected about 20 percent of the boxes packed. Again this added only a small percentage to packing-house labor costs. Subsequent AQSIQ inspections of 5 percent of boxes would add a third small incremental cost, as confirmed by the regulatory representative from the Longkou CIQ. While one industry interviewee expressed concern about the cost and uncertainty for the exporter resulting from multiple testing by the firm, CIQ, and at the importing country border, it was acknowledged that CIQ inspectors have had to reject some loads despite the firms' internal inspection processes.[47] Thus, the multiple inspections had proven necessary to reduce pest risks.

There are also some fixed costs associated with being approved for export. An interviewee from one exporting firm that had decided not to apply for approval for Canada from AQSIQ cited an estimated cost of the approval process in the range of 300,000 yuan (about $40,000). A large proportion of the costs are associated with the facilities evaluation by domestic and foreign inspectors of the potential exporter. The costs are usually shared by the interested exporters so that the more firms the less the burden for each one of them. In addition to the cost of inspection, there are costs related to the application for certificates at different levels of the AQSIQ. The interviewee had concluded that the approval for exporting apples to Canada was not worth this cost given the small size of the Canadian market and relatively fewer interested firms (currently only two firms are registered to export to Canada in Shandong Province). In other cases (e.g., exports of apples to other Asian countries like Thailand), he concluded that the export business would be more profitable owing to larger market demand and thus larger numbers of exporting firms.

In this and several other cases, interviewees spoke of the "tangible and intangible" costs related to seeking approval or continuing in the apple exporting activity. It is important to note that in these interviews both tangible and intangible costs are pecuniary. The tangible costs are those caused by procedures and regulations and are transparent and easy to define and measure.

[47] Depending on the severity of case, the CIQ can reject the shipment or remove the firm from exporting list.

In contrast, the intangible costs are non-transparent and are difficult to document. The intangible costs are usually those incurred through building up relationships between firms and personnel of government agencies. Sometimes this is related to bribery or some other illegal activities. Despite its potential illegal nature, it is important for a firm to engage in this practice, since a success or failure to build a relationship can mean business or no business. Currently, rent seeking behavior is pervasive in the Chinese government and firms of different scales are investing heavily in these intangible costs. In our interviews, respondents indicated that understanding the critical role of relationship with governmental partners and then the costs associated with setting up the appropriated relationship is essential to the survival of the firms in China.

Appendix II: Field Research Itinerary and Interviews

AII.1. Interviews Conducted during the First Field Investigation, July 2006

Name	Title	Affiliation
Beijing (June 19-23, 2006)		
Government agencies		
Yiyu Wang	Director	Department for Supervision on Animal and Plant
Yajun Huang	Associate	Quarantine, General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ)
Puguo Zhou	Director	Department of Crop Production, Ministry of Agriculture (MOA)
Yan Zhong	Director	Division of Animal and Plant Supervision, Beijing Entry/Exit Inspection and Quarantine Bureau
Jinxiu Zhou	Associate	National Development and Reform Commission (NDRC)
Research institutes		
Dongsheng Sun	Director	Division of Trade Research, Chinese Academy of
Shumin Liang	Research Associate	Agricultural Sciences (CAAS)
Dawei Chen	Chief Economist	Beijing WTO Information Center
Huaping Guo	Research Associate	
Shandong Province (June 24-30 , 2006)		
Local government agencies		
Guoqing Qu	Director	Division of Foreign Cooperation, Department of
Ming Yang	Associate Director	Agriculture, Shandong Province
Rubing Guo	Director	Division of Animal and Plant Supervision, Shandong Entry/Exit Inspection and Quarantine Bureau
Longmin Lu	Director	Bureau of Agriculture, Longkou, Shandong Province
Trading companies		
Lin Wang	Manager	Shandong Longkou FHTK Refrigeration Co. Ltd
Tianzhi Suo	President	Longkou Sony Fruit and Vegetable Co. Ltd

AII.2. Interviews Conducted during the Second Field Investigation, July 2007

Name	Title	Affiliation
Beijing (July 8-13, 2007)		
Government agencies		
Song Yang	Director	Center for Standards and Regulations, General
Xinxin Dong	Engineer	Administration of Quality Supervision, Inspection and Quarantine (AQSIQ); WTO/SPS Enquiry Point of China
Yijun Han	Director	Research Center for Rural Economy (RCRE),
Xueling Zhai	Senior Research Fellow	Ministry of Agriculture (MOA)
Foreign embassies		
Mark Petry	Agricultural Attache	US Embassy
Vincent Hudson	Counsellor	Australian Embassy
Catriona Murray	Manager, North Asia	Australian Embassy
Peter Hewitt	Counsellor	Australian Embassy
Andrew Lam	Counsellor	Canadian Embassy
Research institutes & Universities		
Dongsheng Sun	Director	Division of Trade Research and Center for
Xiaohe Liu	Director	Agricultural Trade Policy, Chinese Academy of Agricultural Sciences (CAAS)
Yunlai Xiao	Director	Chinese Academy of Agricultural Engineering
Zhigang Wang	Associate Professor	School of Agricultural Economics and Rural
Yinchu Zeng	Associate Dean	Development, Renmin University
Shandong Province (June 14-19, 2007)		
Local government agencies		
Guoqing Qu	Director	Division of Foreign Cooperation, Department of
Guohua Tang	Associate Director	Agriculture, Shandong Province
Zhikui Wang	Director	Longkou Fruit Tree Station, Bureau of Agriculture,
Xinjie	Associate Director	Longkou, Shandong Province
Guanghai Diao	Associate Director	Bureau of Agriculture, Longkou, Shandong Province
Liu Shan	Division Chief	
Fukai Wen	Inspector	Longkou Entry/Exit Inspection and Quarantine Bureau
Trading companies and packing sheds		
Qi Wang	Deputy General Manager	Shandong Longkou FHTK Refrigeration Co. Ltd
Jie Yang	Senior Agronomist	
Longmin Lu	Deputy General Manager	Longkou Shengxin Fruit &Vegetable Co. Ltd
Changfu Chu	Senior Representative	Longkou Guangyuan Foodstuffs Co. Ltd
Lina Zhang	Technician	
Orchards		
Liangmin Wang	Manager	Longkou Chunlong Orchard

Appendix III. Apple Orchards and Packinghouses Exporting to Canada in 2006/07

AIII.1 Registered Apple Orchards and packinghouses from Shaanxi Province

Name of Registered Apple Orchards	Registered Number	Location of Registered Apple Orchards	Area (ha)	Output (tons)
Lijia	FACH01	Chunhua County Hujiamiao	10.5	320
Wangjiagou	FACH02	Chunhua County Runzhen	6.8	200
Xiangwu	FACH03	Chunhua County Tiewang	8.1	240
Dong'angong	FALC01	Luochuan CountyYongxiang	33.3	1,000
Xialan	FALC02	Luochuan CountyShiquan	40	1,200
Xindian	FAXY01	Xunyi Zhangbasi	13.1	390
Su	FAXY02	Xunyi County Zhangbasi	24	720
Nan'anshan	HSLC01	Luochuan CountyJingzhao	42	1,260
Sanzhuawa	HSLC02	Luochuan CountyJingzhao	25.8	770
Changjiayuan	HSLC03	Luochuan CountyJingzhao	64	1,920
Wulitou	HSLC04	Luochuan CountyJiuxian	46.7	1,400
Guzui	HSLC05	Luochuan CountyFengqi	66.7	2,000
Xi'angong	HSLC06	Luochuan CountyYongxiang	55.9	1,680
Fangxiang	HSLC07	Luochuan CountyHuangzhang	65.3	1,960
Beiyang	HSLC08	Luochuan CountyYangshu	39.3	1,180
Nanyang	HSLC09	Luochuan CountyYangshu	46.7	1,400
Zhangjia	HSXY01	Xunyi County Taicun	66.7	2,000
Shanghuanglou	HSXY02	Xunyi County Zhanghong	112.7	3,380
Pengqi	HSXY03	Xunyi County Zhanghong	82	2,460
Xiwa	HSXY04	Xunyi County Qiupotou	55.3	1,660
Hujia	HSXY05	Xunyi County Chidao	100	3,000
Wangyaoke	HSYC01	Yichuan County Niujiadian	64.7	1,940
Shangcaodi	YALC01	Luochuan CountyHuangzhang	33.3	1,000
Huaibai	YALC02	Luochuan CountyHuaibai	100	3,000
Wali	YALC03	Luochuan CountyHuaibai	66.7	2,000
Banhu	YALC04	Luochuan CountyLaomiao	66.7	2,000
Chewang	YALC05	Luochuan CountyFengqi	100	3,200

Name of Packing House	Registered Number	Abbreviation	Location of the Packing House
Shaanxi Huasheng (Group)	SG-0001	HS	Xi'an, Shaanxi, China
Xianyang Fuan Fruit Juice	SG-0002	FA	Xianyang, Shaanxi, China
Yanan Fruit Group	SG-0003	YA	Luochuan, Shaanxi, China

AIII.2. Registered Apple Orchards and Packinghouses from Shandong Province (all are located in Longkou or Yantai City)

Name of Orchard	Registered Number
Yeji (1)	3705GY008
Yeji (2)	3705GY009
Houzou	3705GY016
Zhangjiagou	3705GY017
Liujia	3703GY035
Xibancheng	3703GY039
Xiwujia Orchard	3705GY030
Houzhuang Orchard	3703GY046
Nanding Orchard	3705GY031

Name of the Packing House	Registered Number
Longkou Fook Huat Tong Kee Refrigeration Co., LTD.	3705GC001
Longkou Shengxing Fruit & Vegetable Co., LTD.	3705GC006

5. Model of Possible China-U.S. Fresh Apple Trade

To evaluate the effects of a change in US regulations to permit importation of fresh apples from China a seven-region partial equilibrium global model was constructed. In the model apples from different sources (countries) are treated as imperfect substitutes in consumption. The regions of the model comprise three net exporters (the US, China and a conglomerate region of Southern Hemisphere exporters (SHE) represented by Argentina, Chile and New Zealand). Net importing regions are non-US North America (NA, comprised of Canada and Mexico), the ASEAN region, the EU-15, and an aggregate rest of world (ROW). The scope of the model is chosen to allow an adequate representation of substitution possibilities within global markets while also facilitating a particular emphasis on the trade quantity and pest risk effects resulting from a change in the US regulations. We concentrate on production, consumption and trade of fresh apples with adjustments to the world production data to account for use of apples for juice and other processed products.

This section is divided into three parts. The first subsection provides a description of the benchmark data which the simulation model is initially calibrated to replicate. The second subsection provides a technical description of the model. The results are presented and discussed in the third subsection.

5.1 Benchmark Data

A set of prices and quantities for the selected regions that represents an initial equilibrium constitute the benchmark data. All prices and quantities are averages from the two-year period January 1, 2003 to December 31, 2004. This specific period was chosen on the basis that Chinese fresh apples were allowed to be imported into Canada from December 2002 and the data from the two major sources, the World Trade Atlas and COMTRADE, are reported by calendar year. The data for the year 2005 was not available for some of the selected regions at the time the analysis was initiated. A two-year base time period is used, the benefit of which compared to a single-year period is that it reduces the chance of choosing an unusual year.

Bilateral Trade Flows

The benchmark bilateral trade flow data for fresh apples is shown in Table 5.1 obtained from World Trade Atlas.[48] This database identifies the six-digit HS categories for trade in fresh apple as well as apple juice (the HS category for fresh apple is 080810).[49] In the table, the exporters spread across rows and the importers are across columns. Bilateral trade flows of fresh apple that are less than 1,000 metric tons are deleted for simplicity. Trade quantities of the ROW composite region are derived by subtracting the summation of the exports or imports of a specific country (or region comprised of specific countries) for all the non-composite countries (or regions comprised of specific countries) from the total exports or imports of each particular country/region.[50] Whether to use the export volume or import flows depends on whether the entry is on the export row or import column of the trade flow table. Intra-regional trade between countries in our aggregated regions (the EU-15, NA, SHE, ASEAN and ROW) is excluded. As shown, trade between our countries/regions accounts for about 50 percent of the world total reported in Appendix I, Table AI.2.

[48] The authors are grateful to Mark Gehlhar, ERS/USDA, who provided access to the trade data.
[49] The Harmonized System (officially Harmonized Commodity Description and Coding System) was adopted by the Customs Co-operation Council in June 1983, and the International Convention on the Harmonized System (HS Convention) came into force on January 1, 1988 (HS88). In accordance with the preamble to the HS Convention, which recognized the importance of ensuring that HS should be kept up to date in the light of changes in technology or in patterns of international trade, HS is regularly reviewed and revised. The categories reported as the baseline data are HS1996 version, which represents the 1996 revision of the Harmonized System (COMTRADE, 2006).
[50] The fresh apple export quantity data for Chile in the year 2003 is not available so the numbers reported in table 5.2 are the import volume of Chilean apples from each importing country. These numbers may be smaller than the actual quantities because of the spoilage during transportation. The total Chinese fresh apple imports for the year 2004 is also unavailable, so an assumption is made that the total imports of fresh apples by China are the same for the year 2003 and 2004.

Table 5.1. Trade of Fresh Apples for Benchmark Regions (metric tons), Averages 2003 and 2004

Exporter	Importer							
	China	US	NA	EU-15	SHE	ASEAN	ROW	Total
China	--	0	2,680	56,087	0	352,232	280,591	691,590
US	19,322	--	212,873	37,517	0	81,417	151,130	502,259
NA	0	33,795	--	0	0	0	7,294	41,089
EU-15	0	0	0	--	0	4,960	526,924	531,884
SHE	24,954	159,731	72,651	476,473	--	22,660	481,208	1,237,677
ASEAN	0	0	0	0	0	--	0	0
ROW	93,583	3,573	22,129	282,325	0	13,476	--	415,086
Total	137,859	197,099	310,333	852,402	0	474,745	1,447,147	3,419,585

Note: Bilateral fresh apple trade flows of less than 1,000 metric tons are deleted for simplicity.
Source: World Trade Atlas, 2006

Total Production and Consumption

The benchmark fresh apple trade flows are put in the broader context of annual production and consumption in the global balance sheet shown in Table 5.2. The basic balance within each country and for the world is that total domestic apple production plus imports of apples in fresh form minus exports of apples in fresh form equals domestic apple supply used for domestic fresh consumption plus processing into products. The level of total domestic apple production for each region is given in the first column of Table 5.2. It is an estimate of the two-year average of apple production derived from the Food and Agriculture Organization (FAO) STAT database. The level of fresh apple production in the ROW composite region is estimated by subtracting the quantity of fresh apples produced in all other regions in the model from the world fresh apple supply. The total import and export quantities of fresh apples (columns 2 and 6, respectively) are taken from the bilateral trade flow Table 5.1.

Derivation of the fresh apple consumption for each region as shown in Table 5.2 requires separating the total apple production and imports less exports in fresh form as reported by FAO into uses for fresh domestic consumption versus processing. Data on domestic consumption and use of apples by the processing industry in each region is obtained from FAS/USDA but is

Table 5.2. Balance Sheet of Fresh Apple Supply and Demand in Benchmark Regions (thousand metric tons), Averages 2003 and 2004

Country/Region	Total Apple Production	Imports of Fresh Apple	Fresh Apples Processed into Products	Apples Available for Fresh Uses	Domestic Fresh Apple Consumption	Exports of Fresh Apples
	(1)	(2)	(3)	(4)	(5)	(6)
China	22,393	138	3,736	18,795	18,103	692
USA	4,324	197	1,569	2,952	2,451	501
NA	906	311	224	993	951	42
EU-15	8,193	853	1,923[1]	7,123	6,590[1]	533
SHE	3,009	0	1,169	1,840	602	1,238
ASEAN	0	476	0	476	476	0
ROW	22,206	1,447	8,785	14,868	14,453	415
World	61,030	3,422	17,406	47,047	43,626	3,421

Note: Data of apples used for domestic consumption and processed industry is not available for Denmark, Ireland, Portugal, Austria, and Finland, therefore the corresponding ratio calculated for EU-15 did not take these five countries into account.
Source: FAOSTAT, World Trade Atlas and authors' calculations

reported by marketing year instead of calendar year. In order to generate the balances of Table 5.2, the total quantity of apples available in each region for domestic consumption and processing on a calendar-year annual basis (columns 1 + 2 – 6) is divided into a processed amount (column 3) and an amount available for fresh domestic consumption (column 4). This is done by applying to the annual data the ratio calculated from the USDA marketing year data of apples consumed by the fresh domestic market versus those used by the processed industry (either for domestic sales or exports of various processed products).

Price Observations

To complete the benchmark data, a set of apple prices are required. For each bilateral trade flow, data is available on CIF import values and quantities, tariffs, and corresponding FOB export values and quantities. From the CIF and FOB data, a set of estimated corresponding CIF and FOB unit prices and international transportation costs can be calculated (Tables 5.3, 5.4 and 5.5).

The unit prices computed from the CIF import values and trade quantities reported in COMTRADE are used as the basis for calibrating the wholesale prices of imported apples for all regions defined in the model. The CIF import values include the transaction value of the goods, the value of services performed to deliver goods to the border of the exporting country and the value of the services performed to deliver the goods from the border of the exporting country to the border of the importing country (COMTRADE, 2006). The CIF values do not take tariffs or the transaction costs incurred in the importing country into account, which should also be part of the wholesale prices. The wholesale prices for this study are defined as the tariff inclusive CIF import prices. The data for the transaction costs within the demand regions is unavailable, so the simplification is made that these costs are ignored for all importing countries. The respective wholesale prices of imported fresh apples corresponding to the bilateral trade flows in Table 5.1 are shown in the off-diagonal entries of Table 5.3. Similar to Table 5.1, the rows of this table represent exporters whereas the columns are importers. For a specific column, the numbers reported down the rows are the tariff-inclusive CIF import prices, or wholesale prices of fresh apples, for that particular region.

The wholesale prices of fresh apples price range from \$375 to \$1,132 per metric ton. High-income countries import mainly high-value fresh apples whereas developing countries tend to purchase low-value apples. For the U.S. and the EU, the wholesale prices of fresh apples are over $900 per metric ton. The price of American fresh apples on the EU market is the highest at $1,132 per metric ton. An exception is the price of NA (Canadian) apples imported by the U.S., which was $689 per metric ton.[51] Low shipping costs and the zero tariff rate imposed by the U.S. on fresh apples explains, to some extent, this lower price.

For developing countries, such as China and ASEAN, the average wholesale prices of imported fresh apples are around $700 per metric ton. The price of Chinese fresh apples on the ASEAN market averages $459 per metric ton, while apples exported by China to the ROW average only $375 per metric ton. Compared to China's apple exports to NA (Canada) and the EU-15, this represents lower-quality, lower priced exports.

Substantial differences in the wholesale prices of fresh apples across regions can be explained by apple varieties and sizes. Generally speaking, bigger apples are more expensive than smaller ones. But a common conclusion is hard to draw for apple varieties because of diverse consumer preferences and production pattern. For example, the Fuji variety is sold at a much higher price compare to Red Delicious in the U.S.; however, it is not the case in China where 60 percent of its annual output is Fuji and Red Delicious is available mainly through importing.

The tariff rates imposed on fresh apples are collected from the United Nations Commission for Trade and Development (UNCTAD) TRAINS database (Table 5.6). The rates used to calculate the wholesale prices are the averages of the most favored nation (MFN) tariff. According to the related literature, both fresh apples and apple juices are imported into the US duty free (TRAINS, 2006 and U.S. Apple Association, 2001), although the imports of Chinese apple juice concentrate have been charged antidumping rates of up to 52 percent under a 2000 ITC decision, as described earlier. For ASEAN and ROW, it is assumed that the tariff rates are the weighted average of the tariffs imposed by the countries that are members of these two composite regions, with the trade volumes providing the weights.

[51] Since Mexico is a net importer of fresh apples, NA apple exports refer to Canadian apple exports.

Table 5.3. Derived Wholesale Prices of Fresh Apples for the Benchmark Regions (dollars per metric ton)

	Importer						
Exporter	China	US	NA	EU-15	SHE	ASEAN	ROW
China	346	-	1,066	911	-	459	375
US	733	661	727	1,132	-	751	766
NA	-	689	796	-	-	-	813
EU-15	-	-	-	985	-	656	627
SHE	700	943	571	1,048	606	692	626
ASEAN	-	-	-	-	-	591	-
ROW	774	956	778	794	-	545	701

Note: 1. The data used to calculate the CIF price of the US is from FAS/USDA instead of COMTRADE.
Source: Author's calculation based on COMTRADE, 2006

Table 5.4. Derived FOB Prices of Fresh Apples for the Benchmark Regions (dollars per metric ton)

	Importer						
Exporter	China	US	NA	EU-15	SHE	ASEAN	ROW
China	-	-	907	575	-	375	259
US	589	-	662	843	-	610	652
NA	-	642	-	-	-	-	692
EU-15	-	-	-	-	-	550	546
SHE	572	737	470	677	-	615	513
ASEAN	-	-	-	-	-	-	-
ROW	569	757	692	517	-	476	-

Source: Author's calculation based on COMTRADE, 2006

Table 5.5. Derived Shipping Cost of Fresh Apples for the Benchmark Regions (dollars per metric ton)

	Importer						
Exporter	China	US	NA	EU-15	SHE	ASEAN	ROW
China	-	-	159	336	-	84	116
US	144	-	65	289	-	141	114
NA	-	47	-	-	-	-	121
EU-15	-	-	-	-	-	106	81
SHE	128	206	101	370	-	77	113
ASEAN	-	-	-	-	-	-	-
ROW	205	200	86	277	-	69	-

Source: Author's calculation

Table 5.6. Tariff Imposed on Fresh Apples for Selected Regions

Importers	Tariff Rate	
China	10.0	
U.S.	0.0	
EU-15	2.8	
NA	14.3	
ASEAN (average)	12.7	
Brunei		0.0
Cambodia		7.0
Indonesia		5.0
Laos		0.0
Malaysia		10.0
Myanmar		15.0
Philippines		7.0
Singapore		0.0
Thailand		10.0
Vietnam		40.0
ROW (average)	18.1	

Source: UNCTAD TRAINS, 2006

The corresponding unit FOB export values reported in COMTRADE for the bilateral trade shown in Table 5.2 are shown on the off-diagonal entries of Table 5.4. The FOB export values include the transaction value of fresh apples and the value of services performed to deliver the fresh apples to the border of the exporting country. As in the case of CIF prices, there are no other domestic marketing costs included in the FOB border prices.

The differences between the unit CIF import prices (without the tariffs) and unit FOB export prices are estimates of international shipping costs (Table 5.5), which constitute market margins and will be assumed to remain constant the simulations of the model. Some special cases arise in assessing this data. For those special cases for which reported FOB prices for one of the two years in our benchmark period are higher than the reported CIF prices, the assumption has been made that the FOB prices and CIF prices are the same as those of the year when the latter is greater than the former for that specific region.[52] [53]

[52] Russia, which is part of ROW, is an exception because FOB prices were always higher than CIF prices for fresh apple trade during the investigated two-year period. This may due to the measurement differences between countries. In order to solve the problem, it was assumed that the CIF/FOB ratio is the same for Russia and EU-15 when importing Chilean apples. The ratio for EU-15 is applied to Russia by multiplying the corresponding CIF price to get the reasonable FOB prices. The CIF/FOB ratio for EU imports of Chilean apples is chosen as the target value

Finally, a set of domestic prices of fresh apple have to be calculated for the benchmark. Estimates are shown by the diagonal elements of Table 5.3. It is assumed that there is a single domestic fresh apple price faced by all producers/consumers (as we are not distinguishing between these prices with domestic marketing margins in the model).

Domestic prices reported on the diagonal in Table 5.3 are constructed as follows. In the absence of consistent domestic prices for all regions, these prices are derived similarly in all cases as averages from the reported unit CIF or FOB values. China, the US, and SHE (Chile, Argentina and New Zealand) are fresh apple exporting countries. Their domestic fresh apple price is estimated as the weighted average of the unit FOB export values. This is based on the assumption that the producers in each exporting country sell, and wholesalers purchase, fresh apples at the average price of exports at the border of that country. The weights are calculated as the shares in the total export volume corresponding to the specific FOB prices. NA, EU-15, ASEAN and ROW are fresh apple importing countries. The price of domestic apples is assumed to be the weighted average of the tariff-inclusive CIF import price and the weights are the shares in the total imports corresponds to the particular CIF prices.

When we undertake simulations, FOB and CIF prices remain linked by the estimated transportation costs. In our analysis, we assume costs for shipping apples from China to the U.S. are the same as to Canada. The policy changes we consider will also affect other existing bilateral trade as markets adjust. In principle, new bilateral trade flows could also arise from the simulated policy changes related to U.S. imports of apples from China. However, we assume that the policy change do not cause new bilateral trade to emerge where it has not occurred in the benchmark period.

Expenditure and Population

Per-capita expenditure and population data are also needed to implement the empirical model. Data is taken from World Development Indicators (2006). For the aggregated regions SHE, EU-15 and ASEAN, total population is the summation of population of each member

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for Russia imports from Chile due to similar geographical distance from Chile to these two regions. For Russian imports from other sources, similar assumptions are made and the target country changes to the one that has the closest distance from the exporting country as Russia.

[53] Another special case is Canada for which FOB prices were higher than CIF prices for imports from the U.S. Similar method used in Russian cases was applied here. The CIF/FOB ratio is assumed the same for Canada and Mexico when importing US fresh apples. This ratio multiplied by the corresponding CIF price was used to get the FOB price for Canadian imports of American apples.

country and per capita expenditure is the weighted average of the per capita expenditure of all the member countries, where the weight is the share of the population of the corresponding member country in the total population of that composite region. For ROW, population is estimated by subtracting the population from all other regions in the model from the world total population and the per-capita expenditure is calculated using the following formula:

(1) $$I_{ROW} = \frac{I_{world} * pop_{world} - \sum_i I_i * pop_i}{pop_{ROW}}, \; i = country_1, \ldots, country_n$$

5.2 Description of the Model[54]

Consumer Demand

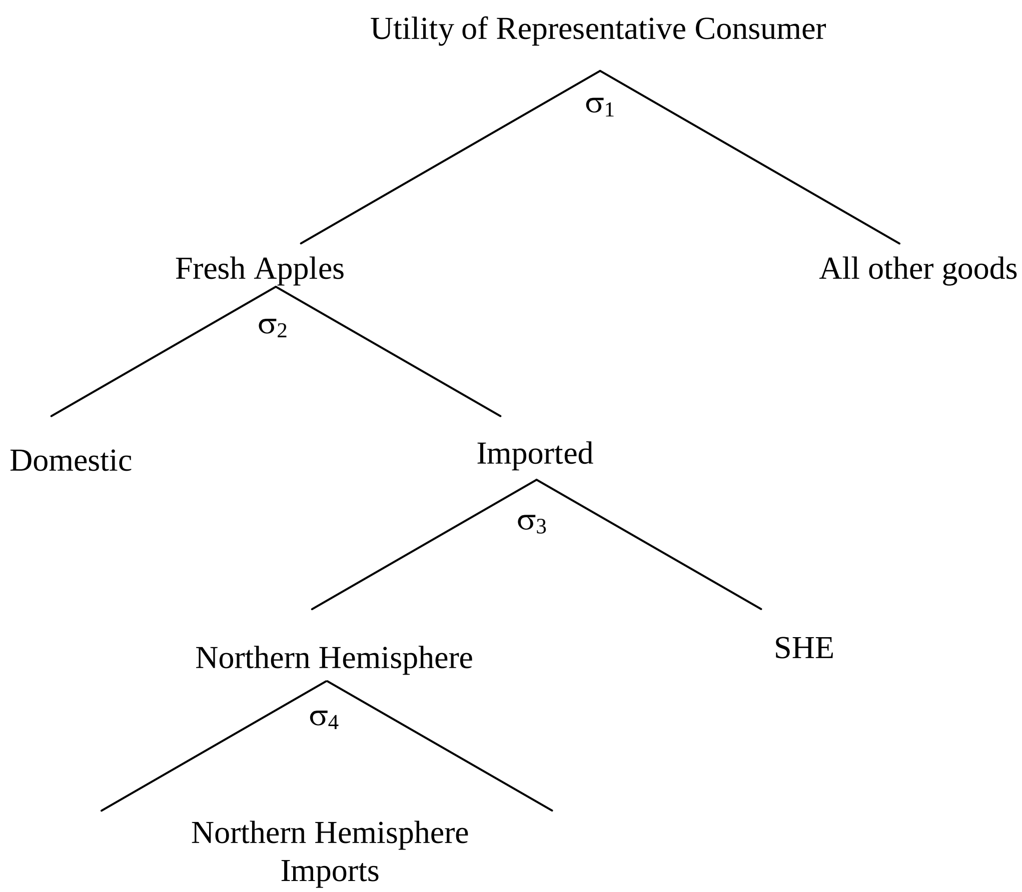
The demand for fresh apples is derived from a weakly separable, nested Constant Elasticity of Substitution (CES) utility function for a representative consumer with purchases partitioned between apples and everything else. Apples from each of the six supply regions are assumed to be imperfect substitutes, due to the different varieties of apples produced in each region. We employ the Armington assumption that apples from domestic producers are viewed by the representative consumer as an imperfect substitute for imported apples. The representative consumer also views apples imported from different supply regions as imperfect substitutes. Because seasonal production patterns may affect the availability of apple imports, we allow the elasticity of substitution between imported apples from northern and southern hemisphere regions to differ from the elasticity of substitution between imported apples from northern hemisphere supply regions.

Figure 5.1 illustrates this preference structure for all demand regions, except SHE and ASEAN, which are discussed below. The parameters σ_4 and σ_3 represents the elasticities of substitution between imported apples from different northern hemisphere supply regions and between imported apples from northern and southern hemisphere supply regions. The parameter σ_2 represents the elasticity of substitution between domestically produced and imported

[54] The model in this section was developed by Everett Peterson. See Peterson and Orden (forthcoming) for a similar model structure and application.

apples.[55] The parameter σ_1 represents the elasticity of substitution between apples from all supply regions and all other goods. An overall decrease in the relative price of apples (represented by a price index) would lead the representative consumer to increase their consumption of apples from all regions.[56] Thus, the value of the parameter σ_1 will determine the magnitude of the aggregate own-price elasticity of demand for avocados in the model.

Figure 5.1. Preference Structure for Representative Consumer in US, NA, EU-15, China, and ROW



[55] In a homogeneous goods model, the parameters σ_2, σ_3, and σ_4 would equal infinity indicating that apples from the different supply regions are perfect substitutes.
[56] The price of all other goods is held constant in the partial equilibrium model, and any change in the apple price index represents a change in relative prices.

For the SHE and ASEAN demand regions, the preference structure in figure 5.1 must be modified slightly. Because no fresh apples are imported into the SHE region, the bottom two nests in Figure 5.1 are not necessary. Similarly, since no fresh apples are produced in the ASEAN region, there are no "domestically produced" apples consumed in that region. The modified preference structures for SHE and ASEAN regions are give in Figures 5.2 and 5.3.

Using the preference structure in Figure 5.1, one can derive the demand functions for all apple types for the U.S., NA, EU-15, China, and ROW demand regions. The demand for domestically produced apples in demand region *i* is:

(2) $$q_{ii} = pop_i \left[\frac{\alpha_i \beta_i wp_{ii}^{-\sigma_2} P_{Ai}^{(\sigma_2-\sigma_1)} I_i}{\alpha_i P_{Ai}^{(1-\sigma_1)} + (1-\alpha_i)} \right] \quad \forall i \neq ASEAN,\ SHE\ ,$$

where α and β are shift parameters, wp_{ii} is the wholesale price of the domestically produced apple, I_i is per-capita income, pop_i is the population of demand region *i*. Note that the price index for all other goods is held constant in the partial equilibrium and may be set equal to one without any loss of generality. P_{Ai} is a CES price index for apples defined as:

(3) $$P_{Ai} = \left\{ \beta_i wp_{ii}^{1-\sigma_2} + (1-\beta_i) P_{Mi}^{1-\sigma_2} \right\}^{\frac{1}{1-\sigma_2}},$$

where P_{Mi} is a CES price index for imported apples in demand region *i*. This index is defined as:

(4) $$P_{Mi} = \left\{ \gamma_i P_{Ni}^{1-\sigma_3} + (1-\gamma_i) wp_{i,she}^{1-\sigma_3} \right\}^{\frac{1}{1-\sigma_3}},$$

where P_{Ni} is a CES price index for imported apples from northern hemisphere regions and $wp_{i,she}$ is the wholesale price of imported apples from the SHE supply region. The index P_{Ni} is defined as:

(5) $$P_{Ni} = \left\{ \sum_j \theta_{ij} wp_{ij}^{1-\sigma_4} \right\}^{\frac{1}{1-\sigma_4}},$$

where *j* is indexed over the US, NA, EU-15, China, and ROW supply regions. The demand functions for imported apples from the SHE and northern hemisphere supply regions are:

(6) $$q_{i,she} = pop_i \left[\frac{\alpha_i (1-\beta_i)(1-\gamma_i) wp_{i,she}^{-\sigma_3} P_{Mi}^{(\sigma_3-\sigma_2)} P_{Ai}^{(\sigma_2-\sigma_1)} I_i}{\alpha_i P_{Ai}^{(1-\sigma_1)} + (1-\alpha_i)} \right] \quad \forall i \neq ASEAN,\ SHE$$

(7) $$q_{ij} = pop_i \left[\frac{\alpha_i (1-\beta_i) \gamma_i \theta_{ij} wp_{ij}^{-\sigma_4} P_{Ni}^{(\sigma_4-\sigma_3)} P_{Mi}^{(\sigma_3-\sigma_2)} P_{Ai}^{(\sigma_2-\sigma_1)} I_i}{\alpha_i P_{Ai}^{(1-\sigma_1)} + (1-\alpha_i)} \right] \quad \forall i \neq ASEAN,\ SHE\ .$$

Figure 5.2. Preference Structure for Representative Consumer in SHE

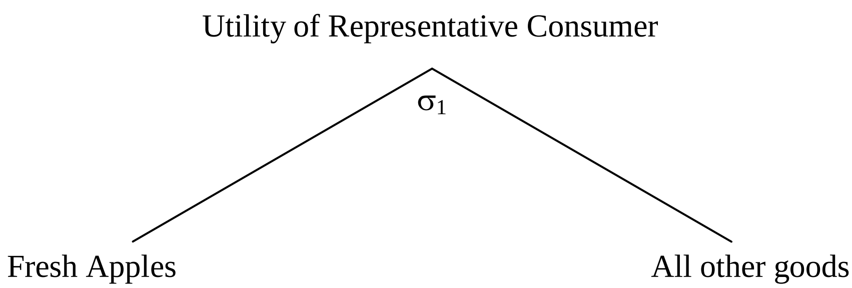
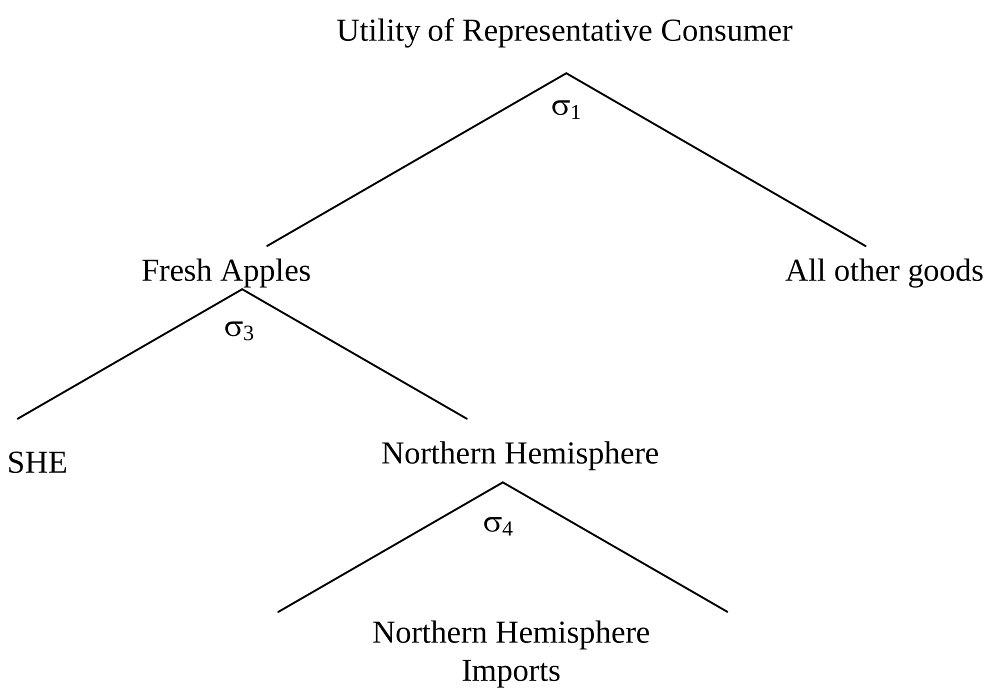


Figure 5.3. Preference Structure for Representative Consumer in ASEAN



The demand function for the SHE region, whose preference structure is given in figure 5.2, is:

(8) $$q_{she,she} = pop_{she}\left[\frac{\alpha_{she} wp_{she,she}^{-\sigma_1} I_{she}}{\alpha_{she} wp_{she,she}^{(1-\sigma_1)} + (1-\alpha_{she})}\right].$$

The demand functions for the ASEAN region, whose preference structure is given in figure 5.3 are:

(9) $$q_{i,she} = pop_i\left[\frac{\alpha_i (1-\gamma_i) wp_{i,she}^{-\sigma_3} P_{Ai}^{(\sigma_2-\sigma_1)} I_i}{\alpha_i P_{Ai}^{(1-\sigma_1)} + (1-\alpha_i)}\right] \quad \forall i = ASEAN \text{ and}$$

(10) $$q_{ij} = pop_i\left[\frac{\alpha_i \gamma_i \theta_{ij} wp_{ij}^{-\sigma_4} P_{Ni}^{(\sigma_4-\sigma_2)} P_{Ai}^{(\sigma_2-\sigma_1)} I_i}{\alpha_i P_{Ai}^{(1-\sigma_1)} + (1-\alpha_i)}\right] \quad \forall i = ASEAN,$$

with *j* being indexed over the US, NA, EU-15, China, and ROW supply regions.

Supply of U.S. Apples

Because there are likely differences in the variety and quality of apples shipped to domestic or export destinations, as indicated by the different values of wholesale and FOB prices for U.S. apples in Tables 5.3 and 5.4, we assume that apples producers supply a differentiated product. A Constant Elasticity of Transformation (CET) production possibilities frontier is utilized to allow the supply of fresh apples to shift between demand regions as the relative producer price (e.g., the price received by producers) changes. In addition, if a pest outbreak were to occur, the production possibilities frontier would shift inward towards the origin, as the pest outbreak reduces the amount of apples produced from a given level of apple specific factors (labor, capital and other inputs). A pest outbreak could also require producers to utilize costly control measures or affect the productivity of the inputs. The revenue function is:

(11) $$R_{us}(pp, V_{us}) = \left\{\sum_i \delta_{i,us}\left(pp_{i,us} - CP\right)^{\lambda}\right\}^{\frac{1}{\lambda}}\left[1 - N * pcteff * PL\right]V_{us},$$

where δ_{ij} is a shift parameter, λ is a parameter that determines the elasticity of transformation, pp_{ij} is the producer price for apples shipped to demand region *i* from supply region *j*, *N* is the frequency of pest outbreak, *CP* is expected per-unit cost of control measures, *pcteff* is the proportion of total acreage affected by an infestation, *PL* is the proportional reduction in productivity caused by an infestation, and V_j is the level of apple specific factors employed. The index *i* represent all demand regions supplied by U.S. apple producers.

The expression *N*pcteff*PL* is the expected pest-related productivity loss. This value is restricted to range between 0 and 1 for positive revenue and outputs. The frequency of a pest outbreak depends on the level of imports, while the proportion of acreage affected and reduction of productivity on this acreage determines the severity of the loss per outbreak. The expression ($pp_{i,us}$ – *CP*) represents the expected net price received by producers after paying for any pest control measures. Because a pest infestation would affect all varieties of apples produced, it is assumed that the costs of control are equally borne across all demand destinations.

The conditional supply functions are derived by taking the derivative of equation (11) with respect to the producer price. This yields:

$$y_{i,us} = \delta_{i,us}\left(pp_{i,us} - CP\right)^{\lambda-1}\left\{\sum_i \delta_{i,us}\left(pp_{i,us} - CP\right)^{\lambda}\right\}^{\frac{1}{\lambda}-1}\left[1 - N * pcteff * PL\right]V_{us}, \tag{12}$$

where $y_{i,us}$ is the quantity of fresh apples supply to demand region *i* by U.S. apple producers. The supply functions in equation (12) are conditional on the level of the apple-specific factor, which determines the location of the CET production possibilities frontier in output space. An increase the net price received by U.S. apple growers, ($pp_{i,us}$ – *CP*), would be expected to increase in the amount of the apple-specific factor used as growers seek to increase the supply of apples. The opposite would be expected if the net producer price decreased. Formally, this relationship is specified as:

$$V_{us} = \mu_{us} + \tau_{us}\left\{\sum_i \delta_{i,us}\left(pp_{i,us} - CP\right)^{\lambda}\right\}^{\frac{1}{\lambda}} \tag{13}$$

where the term in {} is the CET price index from the revenue function in equation (11). The impact of a pest outbreak is to lower the expected net price received by producers due to higher costs of control, thereby lowering the expected price index, leading to a reduction in apple-specific factor utilization.

Costs of U.S. Control Measures and Productivity Losses

Control cost and production losses are considered for U.S. apples for the five pests identified as high risk in four of the five pest assessments reviewed in Section 3. The expected cost of controlling an outbreak will depend on the frequency of an outbreak (*N*), the treatment cost per acre (*ccost*), the percentage of apple production affected by an outbreak (*pcteff*), the productivity loss from an outbreak, and the average apple yield per acre (*yield*). Formally, the expected cost of control per kilogram (*CP*) can be expressed as:

(14) $$CP = \frac{ccost * N * pcteff}{yield * (1 - PL)}.$$

Because the exact values of these variables are not known, based on the description in Section 3, we consider the following ranges in our simulations: *ccost* \$1,800 to \$2,400 per acre, *pcteff* 1% to 5% of total apple production, and *PL* 10% to 25% of average apple yield per acre. The average yield of 10,737 kg per acre was obtained from Table 2.3. Using the average values, the cost of control per outbreak is \$0.007/kg. While the pests identified can infect other fruits as well, we do not consider the losses or potential treatments costs associated with an outbreak that affects other fruits.

Frequency of Outbreak

The frequency (number) of pest outbreaks in the U.S. due to fresh apple imports from China is equal to the probability of an outbreak (*risk*) times the quantity of apples imported from China ($q_{us,china}$). Formally:

(15) $$N = risk * q_{us,china}.$$

Because an estimate of the probability of an outbreak is not available, in the simulations we first assume that there is zero risk. Then, to assess sensitivity of the benefits f rom trade to t he level of risk, we choose the level of *risk* such that the net welfare gain in the U.S. is zero. This would represent the maximum level of pest risk that would be acceptable in order to allow Chinese fresh apples to be imported into the United States if the decision criteria were this expected net expected welfare measure. The lower the probability, the more stringent the design of a systems approach to mitigate pest risk would need to be.

Supply of Fresh Apples From Non-U.S. Regions

Because there are also differences in the domestic wholesale and export FOB prices for other apples exporters, indicating differences in the varieties or quality of apples shipped to different destination, we also assume the apple producers in other regions (besides the U.S.)

supply a differentiated product. The difference between these regions and the U.S. is that producers do not face a new pest risk as do producers in the United States. Thus, the CET revenue functions for the non-U.S. regions do not need to be adjusted for productivity losses, and are specified as:

(16) $$R_j\left(pp, V_j\right) = \left\{\sum_i \delta_{ij} pp_{ij}^{\lambda}\right\}^{\frac{1}{\lambda}} V_j,$$

where j is equal to NA, EU-15, China, SHE, and ROW and i represents the demand regions supplied. The conditional supply functions are derived by taking the derivative of equation (16) with respect to the producer price (pp):

(17) $$y_{ij} = \delta_{ij} pp_{ij}^{\lambda-1}\left\{\sum_i \delta_{ij} pp_{ij}^{\lambda}\right\}^{\frac{1}{\lambda}-1} V_j.$$

Note that the only difference between equations (12) and (17) is the inclusion of the expected control cost in equation (12). Again, the supply functions in equation (17) are conditional on the level of the apple-specific factor. Similar to equation (13), the supply function for the apple-specific factor is specified as:

(18) $$V_j = \mu_j + \tau_j\left\{\sum_i \delta_{ij} pp_{ij}^{\lambda}\right\}^{\frac{1}{\lambda}}.$$

Welfare Measures

Removing restrictions on Chinese fresh apple imports will affect both consumers and producers. For consumers, the concept of equivalent variation is used to quantify these changes. Equivalent variation (EV) refers to the additional amounts of income measured at initial equilibrium prices that would be equal to the price and quantity changes due to the rule. Formally, equivalent variation is defined as:

(19) $$EV = e\left(p^0, u^1\right) - e\left(p^0, u^0\right),$$

where e is the expenditure function, p^0 is the base or current price vector, u^0 is be base level of utility, and u^1 is the level of utility obtained by removing restrictions on Chinese fresh apple imports. The expenditure function for the U.S. representative consumer is derived from the nested CES utility function and is specified as:

(20)

$$e_{us}\left(p,u\right)=\left\{\alpha_{us}\left[\beta_{us}wp_{us,us}^{1-\sigma_2}+\left(1-\beta_{us}\right)\left[\gamma_{us}\left(\sum_j\theta_{us,j}wp_{us,j}^{1-\sigma_4}\right)^{\frac{1-\sigma_3}{1-\sigma_4}}+\left(1-\gamma_{us}\right)wp_{us,she}^{1-\sigma_3}\right]^{\frac{1-\sigma_2}{1-\sigma_3}}\right]^{\frac{1-\sigma_1}{1-\sigma_2}}+\left(1-\alpha_{us}\right)\right\}^{\frac{1}{1-\sigma_1}}u_{us}$$

Note that because the CES utility function is homothetic, the resulting expenditure function is linear in utility. That allows EV to be expressed as:

(21)

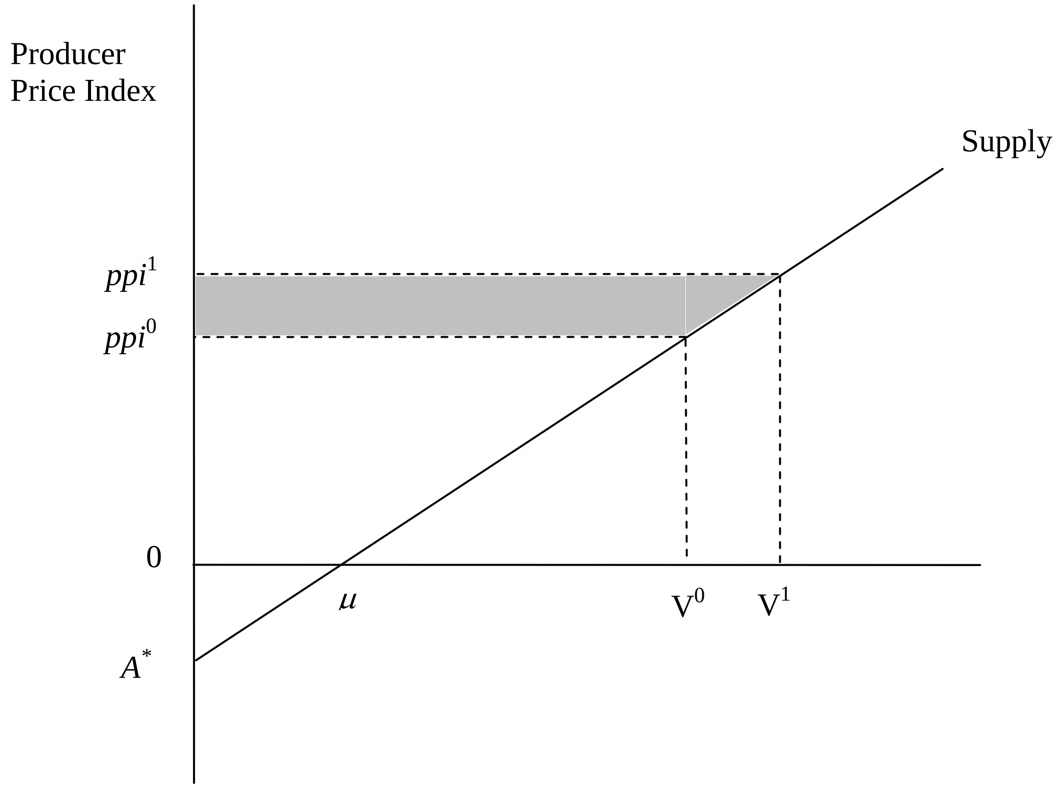
$EV_{us}=pop_{us}*e\left(p_{us}^0\right)*\left(u_{us}^1-u_{us}^0\right)$ where

$$e\left(p_{us}^0\right)=\left\{\alpha_{us}\left[\beta_{us}wp_{us,us}^{1-\sigma_2}+\left(1-\beta_{us}\right)\left[\gamma_{us}\left(\sum_j\theta_{us,j}wp_{us,j}^{1-\sigma_4}\right)^{\frac{1-\sigma_3}{1-\sigma_4}}+\left(1-\gamma_{us}\right)wp_{us,she}^{1-\sigma_3}\right]^{\frac{1-\sigma_2}{1-\sigma_3}}\right]^{\frac{1-\sigma_1}{1-\sigma_2}}+\left(1-\alpha_{us}\right)\right\}^{\frac{1}{1-\sigma_1}}$$

Note that because the expenditure function is for the representative U.S. consumer, it must be multiplied by the U.S. population to obtain the total level of EV. The base level of utility (u_{us}^0) and the level of utility after the lifting of the import restrictions (u_{us}^1) is computed from the indirect utility function. A similar expression for EV also applies to other regions.

The welfare effects for apple producers are determined by computing the change in producer surplus based on the supply curves of the apple-specific factor endowment. The supply of the apple-specific factor is used because it determines the overall level of apple production in a given region and because producer surplus, by definition, is based on the concept of a specific factor of production. The computation of producer surplus is illustrated in Figure 5.4. On the vertical axis is the CET price index from the apple-specific factor supply function (see equations (13) and (18)) and on the horizontal axis is the quantity of the apple-specific factor supplied. The parameter μ_j is the intercept term from equations (13) and (18) and τ_j is the slope of the supply function. Denoting the ppi^0 as the CET price index using the benchmark producer prices, V^0 as the initial quantity of the apple-specific factor supplied, the initial level of producer surplus is given by the area of the trapezoid $0ppi^0V^0\mu$. If producer prices increase, leading to an increase in the CET price index to ppi^1 and an increase in the supply of the apple-specific factor

Figure 5.4. Computing Producing Surplus



to V^1, producer surplus increases to the area of the trapezoid $0ppi^1V^1\mu$. The change in producer surplus is then the difference in the area of these two trapezoids, or the shaded area in figure 5.4. To simplify the computation of the change in producer surplus, we compute A^* in figure 5.4, which is the value of CET price index when V is equal to zero.[57] The change in producer surplus then may be computed as the difference between the triangles $A^*ppi^0V^0$ and $A^*ppi^1V^1$. Formally, this may be expressed as:

(22) $$psur = 0.5 * \left[\left(ppi^1 - A^* \right) V^1 - \left(ppi^0 - A^* \right) V^0 \right],$$

where *psur* is the change in producer surplus for a given region.

[57] The value of A^* is computed by setting equation (13) or (18) equation to zero and solving for the CET price index. This equals $-\mu_j / \tau_j$.

Model Calibration

The parameters in the supply and demand equations are chosen to replicate the initial equilibrium identified in the benchmark data while satisfying a set of elasticities obtained from the literature. Unfortunately, little empirical evidence exists on the magnitudes of the supply and demand elasticities for apples across regions, particularly for the aggregate regions that are utilized in this report. Our starting point will be the demand and supply elasticities used by Devadoss and Wahl (2004).

Demand Calibration

Devadoss and Wahl assumes that apples are a homogenous commodity and specifies a single demand elasticity for all apples consumed in each region. Because in our model, domestically produced apples comprise the vast majority of total fresh apple consumption in all regions, except for ASEAN, we apply the elasticities from Devadoss to the own-price demand elasticity for domestically produced apples. For ASEAN, we apply the elasticity as an own-price elasticity of fresh apple imports from China, which comprise nearly three-quarters of total fresh apple consumption in that region. We calibrate preferences in each region to the following elasticities: -0.3 for the US, EU-15, and SHE; -0.4 for NA and ROW; -0.27 for China; and -0.56 for ASEAN.

Using the elasticity form of the Slutsky decomposition, the own-price elasticity of demand (ε_{ii}) can be expressed as a function of its cost share (s_i), the own-price Allen partial elasticity of substitution (σ_{ii}), and the good's income elasticity (η_i). Formally:

(23) $$\varepsilon_{ii} = s_i\left(\sigma_{ii} - \eta_i\right).$$

For the nested CES preference structure in figure 5.1, the value of σ_{ii} for domestically produced fresh apples is equal to:

(24) $$\sigma_{ii} = -\left[\sigma_2\left(s_i^{-1} - s_A^{-1}\right) + \sigma_1\left(s_A^{-1} - 1\right)\right],$$

where s_A is the cost share for all apples. With only one elasticity estimate and the value of σ_{ii} being a function of σ_1 and σ_2, we must choose one of these values before calibrating the value of the other parameter. Combining equations (23) and (24), and solving for σ_2:

(25) $$\sigma_2 = \frac{-\left[\varepsilon_{ii}s_i^{-1} + \sigma_1\left(s_A^{-1} - 1\right) + 1\right]}{\left(s_i^{-1} - s_A^{-1}\right)}.$$

Note that because the nested CES utility function is homothetic, all of the income elasticities of demand are equal to one. In this report, we assume that the value of σ_1 equals 0.2 for all regions because we believe that the substitution between fresh apples (or most foods) and all other goods would be inelastic. The calibrated values of σ_2 are listed in Table 5.7.

Table 5.7. Base Model Parameter Values

	Parameter					
Region	$\boldsymbol{\sigma_1}$	$\boldsymbol{\sigma_2}$	$\boldsymbol{\sigma_3}$	$\boldsymbol{\sigma_4}$	$\boldsymbol{\sigma_T}$ [a]	$\boldsymbol{\eta_s}$ [b]
US	0.2	1.15	0.5	2.3	-2.0	0.8
NA	0.2	0.9	0.5	1.8	-2.0	0.8
EU-15	0.2	1.0	0.5	2.0	-2.0	0.8
China	0.2	4.1	0.5	5.0	-2.0	0.8
SHE	0.2				-2.0	0.8
ASEAN	0.2		0.5	1.33	-2.0	0.8
ROW	0.2	2.5	0.5	5.0	-2.0	0.8

Notes: [a] Elasticity of transformation in CET revenue function; [b] Aggregate supply elasticity for fresh apples.
Source: Authors' calculations

The values of σ_3 and σ_4 must also be specified to implement the model. Because of the differences in seasonal availability of fresh apples from northern and southern hemisphere exporters, we assume that elasticity of substitution between these types of fresh apples would tend to be inelastic. We assume that σ_3 equals 0.5 for the US, NA, EU-15, China, and the ROW. Because we believe that the elasticity of substitution between fresh apples imported from northern hemisphere regions would tend to be elastic and larger than the value of σ_2, except for China, we set the value of σ_4 equal to $2\sigma_2$. Because the calibrated value of σ_2 for China is fairly large at 4.1, we do not set σ_4 equal to double its value. Rather, we set the value of σ_4 equal to 5.0, which is the largest value of σ_4 in the other regions. Table 5.8 lists the uncompensated demand elasticities for the U.S., NA, EU-15, and China. Note that the assumption of a relative small value for σ_3 leads to imported fresh apples from SHE and northern hemisphere regions to be complements.

Table 5.8. Uncompensated Demand Elasticities for Selected Regions

	Region[a]					
Region	US	NA	EU-15	China	SHE	ROW
			US			
US	-0.3	0.01			0.09	0.002
NA	0.85	-0.80			-0.47	0.22
EU-15						
China						
SHE	0.85	-0.07			-0.97	-0.01
ROW	0.85	1.50			-0.47	-2.08
			NA			
US	-0.79	0.49		0.02	-0.04	0.11
NA	0.15	-0.40		0.00	0.04	0.02
EU-15						
China	1.01	0.49		-1.78	-0.04	0.11
SHE	-0.14	0.49		0.00	-0.54	-0.02
ROW	1.01	0.49		0.02	-0.04	-1.69
			EU-15			
US	-1.82		0.70	0.22	-0.24	0.95
NA						
EU-15	0.01		-0.30	0.01	0.06	0.03
China	0.18		0.70	-1.78	-0.24	0.95
SHE	-0.02		0.70	-0.02	-0.74	-0.11
ROW	0.18		0.70	0.22	-0.24	-1.05
			China			
US	-4.75			3.83	-0.59	1.30
NA						
EU-15						
China	0.01			-0.27	0.01	0.04
SHE	-0.48			3.83	-1.09	-2.46
ROW	0.25			3.83	-0.59	-3.70

Notes: [a] Cells with no values represent demand and supply pairs with zero consumption in benchmark data.
Source: Authors' calculations

(26) $$\sigma_1 = \frac{-\left[\varepsilon_{ii} s_i^{-1} + 1\right]}{\left(s_i^{-1} - 1\right)},$$

and its value is reported in table 5.8. Note that because the SHE region does not import any fresh apples, the cost share of domestically produced apples (s_i) is also equal to the cost share of all apples (s_A).

Based on the preference structure in figure 5.3, the own-price Allen elasticity of substitution for Chinese fresh apple imports into the ASEAN region is:

(27) $$\sigma_{ii} = -\left[\sigma_4\left(s_i^{-1} - s_N^{-1}\right) + \sigma_3\left(s_N^{-1} - s_A^{-1}\right) + \sigma_1\left(s_A^{-1} - 1\right)\right],$$

where s_N is the cost share of all fresh apples imported from northern hemisphere regions. With σ_{ii} being a function of three unknown parameters, we must choose two of these values and calibrate the third value. For consistency across regions, we assume that σ_1 equals 0.2 and σ_3 equals 0.5 and then calibrate the value of σ_4. Thus:

(28) $$\sigma_4 = \frac{-\left[\varepsilon_{ii} s_i^{-1} + \sigma_3\left(s_N^{-1} - s_A^{-1}\right) + \sigma_1\left(s_A^{-1} - 1\right) + 1\right]}{\left(s_i^{-1} - s_N^{-1}\right)}.$$

Once the values of σ_1, σ_2, σ_3, and σ_4 have been determined for each region, then the values of the shift parameters (α_i, β_i, γ_i, and θ_{ij}) are calculated such that the CES demand functions can replicate the initial quantities demanded in the benchmark data.

Supply Calibration

Two key parameters must be chosen when calibration the supply functions in the model: the elasticity of transformation and the aggregate supply elasticity for fresh apples. No empirical estimates exist for the elasticity of transformation. In the absence of strict trade barriers, apple producers should be able to shift apple production across different destinations relatively easily. Thus, we assume that the elasticity of transformation is equal to -2.0. Devadoss and Wahl (2004) report supply elasticity estimates for all apples for different regions, and these estimates vary widely, from 0.054 to 1.277. Given the biological time lags from the planting of new trees to the realization of new production, it is not clear why there is a large variability in the supply elasticities. However, the supply elasticities for three main exporters, China, Argentina, and New Zealand, were all approximately 0.4. So we view this as a realistic supply elasticity estimate for all regions. But since our model only includes fresh apples, and the Devadoss supply elasticities are for all apples, we adjust the supply elasticity upward to account for the potential substitution of apples between different end users (e.g., fresh consumption versus processed apple products). Thus, we assume that the fresh apple supply elasticity is 0.8 in all regions.

Given the assumed elasticity of transformation, the values of the shift parmeters (δ_{ij}) in the CET revenue function and the initial level of the apple-specific factor (V_j) are chosen such that the conditional supply functions replicate the benchmark data. Once an initial value for V_j is determined and given an initial value of the CET price index, the slope (τ_j) parameter in the apple-specific factor supply function is chosen to replicate the fresh apple supply elasticity. Then the intercept (μ_j) parameter is determined to ensure that the value of the linear supply function for the apple-specific factor at the initial CET price index is equal to the calibrated value of V_j.

5.3 Model Results

To assess the potential economic and pest-risk effects of the removal of import restrictions on fresh apples imports from China into the Unites States requires estimates of the potential penetration of fresh Chinese apples into the U.S. market and the potential magnitudes of pest outbreaks. As will be discussed below, in this assessment we assume that in the short-run Chinese fresh apple imports would achieve a market share similar to the market share of Chinese apples in NA in the benchmark data. This reflects the preference of Canadian consumers toward China for apples that were able to meet the phytosanitary requirement under Canadian import regulations. Because the probability of a pest outbreak (*risk*) due to the importation of fresh apples from China in the U.S. is not known, after calculating welfare gains from trade with zero risk assumed, we determine the maximum probability level that might leave U.S. policymakers indifferent on whether to grant Chinese access to the U.S. market, on the basis that the change in U.S. welfare from granting market access to Chinese fresh apples would be approximately equal to zero.

Modelling the Removal of Import Restrictions

Simulating the removal of U.S. import restrictions on the importation of fresh apples from China requires that shift parameters of the CES utility function for the representative consumer in the U.S. and the shift parameters for the CET revenue function for apple producers in China must be adjusted from their initial zero values, which are used to match the absence of fresh apple trade between the U.S. and China in the benchmark period. Without historical trade data on which to base a forecast, we choose the values of the CES and CET shift parameters such that the Chinese achieve a market share similar to their current market share in NA (Canada) at a producer price similar to the FOB price of Chinese apple exports to the EU, which also has relatively low tariffs compared to NA in the benchmark data. Although lower than the price of Chinese fresh apples in Canada, the FOB price for exports to the EU is approximately \$0.23/kg (66 percent) higher than the producer price for Chinese fresh apples destined for the Chinese domestic market. This price differential is somewhat larger than the range of estimates from Chinese producers of the additional costs required to satisfy phytosanitary regulations for fresh apple exports to the EU (see Section 4), so other factors are also affecting the market. One of these factors is that the imported apples from China are a specialty product compared to apples from domestic and other import sources.

The parameter θ_{ij} in the CES utility function for the representative consumer in the United States is adjusted when removing U.S. import restrictions. In the benchmark data, the U.S. imported fresh apples from NA and ROW only. Given the elasticities of substitution and initial wholesale prices, the initial values of θ_{ij} are calibrated to equal approximately 0.817 for NA and 0.183 for ROW. When adjusting these initial parameter values to allow market access for Chinese fresh apples, we maintain the relative preference bias between fresh apples from NA and the ROW. In order to achieve a market share of approximately 0.3 percent for Chinese fresh apples at a wholesale price of approximately \$0.73/kg in the U.S., the values of θ_{ij} are adjusted to equal 0.6125 for NA, 0.25 for China, and 0.1375 for ROW.

In the CET revenue function for Chinese fresh apples, the parameters δ_{ij} are adjusted from their calibrated values. Again, because of the existing import restriction, $\delta_{us,china}$ equalled zero initially. To achieve the target market share mentioned in the previous paragraph and a Chinese producer price of approximately \$0.57/kg, the value of $\delta_{us,china}$ is set equal to 0.00015. Because δ_{ij} must sum to one and because market access to the U.S. would likely reduce fresh apples available in the Chinese domestic market, we adjust the value $\delta_{china,china}$ from 0.95625 to 0.95610 in our simulations.

Simulation Results

The adjustment in the CES and CET shift parameters discussed above yields fresh apple imports of Chinese apples into the United States of approximately 7,850 metric tons, or a market share of 0.0032 (0.32 percent) for all scenarios (see Table 5.9). Introducing a new source of imports into the CES sub-utility function for imports from northern hemisphere countries causes the price index for that sub-utility function, $P_{N,us}$, to decrease by approximately 6 percent in all scenarios. Because $P_{N,us}$ is a part of the U.S. price index for imported apples, $P_{M,us}$, this price index also decreases by 0.7 percent. The smaller decrease in $P_{M,us}$ relative to $P_{N,us}$ is because there is no change in the wholesale price of imported apples from SHE and this price has a larger weight in $P_{M,us}$ due to the larger relative consumption of fresh apples from SHE compared to fresh apples imported from northern hemisphere regions. The decrease in $P_{M,us}$ relative to the wholesale price of domestically produced apples causes the U.S. representative consumer to substitute imported apples for domestically produced apples. This leads to a reduction in consumption of approximately 2,900 Mt (0.13 percent) of domestically produced fresh apples in the United States if there is no pest risk. Because the domestic market is the largest consumer of fresh apples produced in the U.S., this drop in demand leads to a $0.001/kg (0.15 percent) decrease in the producer and wholesale prices of domestically produced apples sold in the United States. Because the relatively small level of fresh apple trade between China and the U.S. does not lead to significant changes in producer or wholesale price levels in any region, the impacts on global apple trade are minimal. With little change in apple exports and with a decline in domestic consumption, the production of apples in the U.S. declines by approximately 2,850 metric tons.

In the scenario where there is no risk of a pest outbreak from the importation of fresh Chinese apples into the United States, there is a very small net welfare gain of $931,000 in the Unites States. Because the CES utility function is "variety loving," the availability of a new apple type in the U.S. leads to an increase in utility. However, due to the relatively small level of imports from China and because these imports are relatively more expensive than domestically produced apples and imports for NA, the increase in utility for the U.S. representative consumer is relatively small. Overall, there is a $3.288 million increase in EV for the United States. Because of the $0.001/kg decrease in the producer price for U.S. apples sold domestically, the

Table 5.9. Apple Model Simulation Results

Variable	Base Case	No Risk	Cost of Control Low[a]	Cost of Control Average[b]	Cost of Control High[c]
Production			(Thousand Metric Tons)		
US	2755.875	2753.020	2752.429	2752.214	2752.355
China	18657.016	18661.116	18661.162	18661.177	18661.168
Consumption[d]					
(US,US)	2253.789	2250.901	2250.535	2250.402	2250.489
(US,China)	0.000	7.846	7.849	7.850	7.850
(US,Other)	197.328	191.921	191.982	192.003	191.989
(China,China)	17965.008	17961.467	17961.465	17961.463	17961.465
(China,Other)	118.831	118.855	118.856	118.855	118.856
Wholesale Price			($/kg)		
(US,US)	0.661	0.660	0.6604	0.6604	0.6603
(US,China)	--	0.736	0.737	0.737	0.737
Producer Price					
(US,US)	0.661	0.660	0.660	0.660	0.660
(US,China)	--	0.577	0.578	0.578	0.578
(EU,China)	0.575	0.575	0.575	0.575	0.575
(China,China)	0.346	0.346	0.346	0.346	0.346
Frequency of Outbreak	--	--	0.196	0.063	0.0235
Risk per kg	--	--	2.5E-08	8.0E-09	3.0E-09
Cost of Control ($/kg)	--	--	$0.000365	$0.000446	$0.00035
Equivalent Variation			(Millions Dollars)		
US		3.288	2.453	2.276	2.276
China		-1.377	-1.394	-1.400	-1.394
Producer Surplus					
US		-2.357	-2.399	-2.273	-2.237
China		2.581	2.602	2.610	2.604
Net Welfare					
US		0.931	0.054	0.003	0.039
China		1.204	1.208	1.210	1.210

Notes:

[a] $1,800 per acre control costs, 10% productivity loss, 1% of total apple acres affected.
[b] $2,100 per acre control costs, 17.5% productivity loss, 3% of total apple acres affected.
[c] $2,400 per acre control costs, 25% productivity loss, 5% of total apple acres affected.
[d] Regions in parentheses refer to the demand region and supply region.

Source: Authors' calculations

producer surplus for U.S. apple producers' decreases by $2.357 million. There is also a modest net welfare gain in China of $1.204 million. Because of the ability to sell fresh apples to the U.S. at a higher price than the domestic market in China lead to an increase in producer surplus of $2.581 million for Chinese apple producers. Conversely, with slightly less fresh apples available to consumers in China, EV decreases by $1.377 million in China.

Because the increase in U.S. net welfare without pest risk is so small, the level of pest risk does not need to be very large in order to eliminate that welfare gain. With our assumption of the minimal low cost of control, low productivity losses, and a small acreage affected by an outbreak, the maximum probability of an outbreak (*risk*) of 2.5E-8/kg would leave U.S. welfare essentially unchanged fro opening the U.S. domestic market to Chinese fresh apples. If the probability of an outbreak is less than 2.5E-8/kg, then the U.S. would enjoy a net expected welfare gain even with risk. If the probability of an outbreak exceeded 2.5E-8, then allowing access would lead to a decrease in U.S. net welfare. As the cost of control, productivity losses, and acreage affected increase, the maximum allowable risk decreases. Going from assumed "low costs" to assumed "average costs," the maximum allowable risk that leaves welfare essentially unchanged decreases by an order of magnitude to 8.0E-9/kg. Further increases in the costs of control to "high levels," reduce the maximum allowable risk by nearly a third to 3.0E-9/kg. [58]

With a relatively small level of fresh apple imports from China in the United States and a low risk probability, the frequency of outbreaks are also relatively low. In the case of "low costs," with the risk probability that leaves welfare unchanged, the expected frequency is approximately 0.2 per year or one every five years. For the cases of "average cost" and "high cost," with smaller maximum risk probabilities, the expected frequency of an outbreak drops to 0.06 and 0.02 per year, respectively. With these small frequencies, the expected cost of control is also very small; about $0.0004/kg across all three risk scenarios.

Because the supply of domestically produced fresh apples in the U.S. is relatively more elastic than the demand for domestically produced apples, most of the expected cost of control is passed on to consumers. So while the price received by U.S. producers remains constant across all scenarios, the wholesale price of U.S. fresh apples increases by expected cost of control. This

[58] As a comparison, the risk levels estimated by APHIS (USDA/APHIS, 1996) for the importation of fresh avocados from Mexico into the United States ranged between 3.9E-9/lb. and 3.9E-10/lb when no risk mitigation practices were implemented (see Peterson and Order, forthcoming). These per-pound risks fell to lower levels when a systems approach to pest risk mitigation was imposed, as the case for avocado imports.

increase in the wholesale price leads to a larger reduction in the consumption of domestically produced apples, compared to the no risk scenario. In addition, this reduction in consumption leads to a smaller increase in EV in the United States compared to the no risk scenario. U.S. producer surplus remains virtually unchanged across all scenarios. Thus it is the reduction in EV that results in the net welfare gains for the U.S. going to zero for the pest risk scenarios.

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