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International Trade Commission

Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels, Vol. 2

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Executive Summary

Plant protection products, including pesticides, are important to agricultural producers working to ensure crop production for expanding populations in the United States and in foreign markets. The use of these pesticides, which include insecticides, fungicides, rodenticides, and herbicides, can leave pesticide residues on crops and food products.

Governments seek to regulate pesticide residues to ensure that agricultural products are safe to consume and are not harmful to human, animal, or plant life or health. They require that a pesticide or the active ingredient/substance in a pesticide be approved for use before establishing a maximum residue level (MRL) for each specific pesticide/crop combination. An MRL is the highest level of a given pesticide's residue on a given crop that is legally tolerated in a government's jurisdiction.[1] Tens of thousands of MRLs exist worldwide since each MRL is specific to a pesticide/crop combination.

Stakeholders throughout the world's agricultural supply chains are concerned with the differences in MRLs across markets, including when they are missing or low. However, what constitutes a "missing" or "low" MRL is not strictly defined by the agricultural trade community. Generally, agricultural exporters consider MRLs to be "missing" when a market to which they wish to export does not have an MRL for the pesticide/crop combination that they use/produce. There are several reasons why MRLs may be missing in a particular importing market: for example, a particular pesticide may not be registered in the market for use on any crops, or if the pesticide is registered for use, it may not have established an MRL for a specific crop, or the market may not have adopted an existing Codex MRL for a pesticide/crop combination.

According to many stakeholders in the United States and worldwide, pesticide-related policies in some countries are creating significant challenges to agricultural trade. Farmers are increasingly adjusting production practices in response to evolving policies and regulations governing MRLs on agricultural products. These policy and regulatory changes, and the associated uncertainty, can negatively affect farmers' costs as well as their ability to access export markets, which may affect their income. The impacts from missing or low MRLs can vary by country and may be particularly problematic for farmers exporting minor or specialty crops,[2] which have fewer existing MRLs. This is discussed in further detail in chapter 2 of this report.

The U.S. Trade Representative (USTR) requested the U.S. International Trade Commission (USITC or Commission) to conduct an investigation and prepare a two-volume report on the global economic impact of pesticide MRLs on farmers around the world. The scope of this investigation is limited to pesticide and MRL policies related to food crops. The first volume included descriptions of the approaches, regulations, and practices of national and international bodies in setting MRLs and

[1] This MRL definition is used by the Codex Alimentarius Commission (an international standard-setting body discussed later in this report) and major agricultural markets, including the United States and the European Union. EPA, "About Pesticide Tolerances," September 16, 2016; Codex, "Maximum Residue Limits (MRLs)," 2018; European Commission, "Maximum Residue Levels" (accessed February 20, 2020).

[2] The United States defines specialty crops as "fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops (including floriculture). These crops include plants that are "cultivated or managed and used by people for food, medicinal purposes, and/or aesthetic gratification." Specialty Crop Competitiveness Act of 2004, Pub. L. No. 108-465, § 3 (2004); USDA AMS, "What Is a Specialty Crop?" (accessed February 25, 2020).

governing pesticide use. The first volume also covered challenges and concerns faced by industry stakeholders in meeting export market MRLs and the costs and effects of compliance and noncompliance with those MRLs for producers in a range of countries. This second volume of the report provides economic modeling assessments exploring the impact of low and missing MRLs on trade, production, and farm income. This second volume also includes U.S. crop case studies describing the effects of low and missing MRLs on a variety of fruits, vegetables, and other specialty crops. It describes the impact of compliance and noncompliance with export market MRLs on U.S. production and export of these products and notes the impact of low and missing MRLs on the integrated pest management (IPM) programs used by growers in several U.S. agricultural sectors.

The regulation of pesticide residues can be a sensitive subject. It is therefore important to place our findings in this report in context. The United States has long and consistently recognized the right of nations to regulate to protect human, animal, and plant life and health, as well as the environment.[3] In the text of its trade agreements, for example, the United States has recognized that each party has the right to determine for itself what level of protection is appropriate for its own people.[4] At the same time, the United States includes in its trade agreements provisions for parties to avoid creating "unnecessary obstacles to trade," to base their decisions on science, and when they regulate, to do so transparently and in accordance with good regulatory practices.[5]

Pursuant to the USTR's request, the report in its two volumes examines the many challenges and concerns U.S producers and producers in other exporting countries face with respect to compliance and noncompliance with MRLs, and the costs agricultural producers incur as a result of low and missing MRLs. The Commission was not asked to determine whether various MRLs around the world are science-based, are developed transparently and in accordance with good regulatory practices, or create "unnecessary obstacles" to international trade. Instead, our report is best viewed as helping to answer the relatively more straightforward part of a more difficult question. Putting aside whether they are necessary or unnecessary, what kind of "obstacles" (challenges and costs) do missing and low MRLs create, and what is the magnitude of those costs? Thus, the report does not undertake a critique of pesticide regulations. Rather, as requested, it assesses and describes the economic costs and trade effects associated with those regulations. Understanding those costs and effects is important as governments develop and implement the pesticide regulations that they consider appropriate to protect human health and the environment.

Costs and Effects of Missing and Low MRLs: U.S. Producer Case Studies

Case studies included in the report describe the actual and potential costs and effects associated with missing or low MRLS, based on interviews with industry representatives and producers. These case studies incorporate the perspective of U.S. producers of a diverse range of specialty crops grown in different regions of the United States, and shipped to a wide variety of export markets. Summarized

[3] See, e.g., WTO SPS Agreement, Art. 2; USMCA, Preamble; USMCA, Art. 9.3.1(a). USMCA is the most recently concluded U.S. trade agreement.
[4] See, e.g., USMCA, art. 9.6.4(a).
[5] See, e.g., USMCA, Preamble; USMCA, art. 9.3.1; USMCA, art. 9.6, USMCA, art. 9.13, USMCA, art. 28.2.

below, the case studies encompass a number of highly perishable fresh fruits and vegetables as well as products such as hops and nuts, which have a longer shelf life, and illustrate how compliance and noncompliance with import market MRLs affect U.S. farmers.

Highly perishable specialty crops are often disproportionately affected by findings of noncompliance, given how quickly their quality can deteriorate while exporters await further testing or attempt to find alternate markets for rejected shipments. Specialty crops with longer shelf lives, on the other hand, face challenges related to the time a crop is in the "channels of trade" (i.e., the time between the crop's harvest and its sale to a buyer). This is due to the possibility that an MRL may change between the time the crop is grown and the time the processed product is exported or consumed. Regardless of perishability, specialty crops are often disproportionately affected by MRL issues, including when MRLs are missing, low, or diverging. This is in part because specialty crops are generally minor crops. Minor crop issues, such as a limited availability of pesticides and MRLs, are explored in greater detail in volume 1, both in chapter 4 and in several foreign producer case studies in chapter 5 of that volume, as well as in chapter 2 of this volume.

The costs and effects of divergent, missing, or low MRLs vary widely, and depend on a variety of factors. These include whether producers choose to bear the costs of complying with the importing market MRL or whether they choose not to comply and lose access to that market as a result. This decision and the costs involved depend on the availability of effective pesticides as alternatives to the pesticides for which MRLs are missing or low, as well as the capacity of the producer to adjust to missing or low MRLs given pest pressure or growing season conditions.

Missing, low, or diverging MRLs can also have significant impacts on farmers by disrupting IPM programs designed to control pests and diseases. IPM programs focus on long-term prevention of pests using a variety of pest management tools such as habitat manipulation, modification of agricultural cultural practices, the use of resistant varieties, and biological controls in addition to chemical controls.[6] These programs use information about pest life cycles and how they interact with the environment to manage the pest damage while minimizing production costs to farmers and impact to the environment and human and animal health.[7] In most cases, however, cultural and other farming practices are not sufficient to manage pest pressures; pesticide use is part of most IPM programs. The aim of IPM is "the

[6] Biological controls are the use of natural enemies of the pest, and cultural controls are grower practices that reduce pest establishment, reproduction, dispersal, and survival. Beneficial insects are an example of biological controls in an IPM system. For example, the green lacewing (scientifically known as *Chrysoperla rufilabris*) is widely used in various situations to control many different pests, including aphids and the eggs of other insects. After an adult lacewing lays its eggs on a crop, the predatory lacewing larvae feed directly on the pest or its eggs. Asparagus farmers in Peru use green lacewing to control pests, such as the lesser cornstalk borer, that feed on and damage asparagus. Green lacewing larva are also released to help control aphids in strawberries and are used in California. While biological controls can help to keep pest numbers low, insecticide applications may still be necessary. UC IPM, "What Is Integrated Pest Management (IPM)?," accessed August 26, 2020; industry representative, interview by USITC staff, Peru, December 9, 2019; Beneficial Insectary, "Green Lacewing," accessed December 3, 2020.; UC IPM, "Agriculture: Strawberry Pest Management Guidelines," accessed December 3, 2020.
[7] EPA, "Integrated Pest Management (IPM) Principles," September 28, 2015.

judicious use of pesticides" when it is determined through monitoring that pesticide use is required, and the goal is to use a pesticide to remove only the targeted organism.[8]

U.S. industry representatives increasingly cite concerns that recent actions in key U.S. export markets to lower pesticide use could disrupt IPM programs that are of critical importance to domestic agricultural industries. These programs are costly to develop and are the result of years of research. When the ability to use a pesticide that is part of IPM program is lost due to reduction or removal of an MRL, it can disrupt the entire IPM program, which can lead to higher costs as producers turn to more expensive or less effective alternative pesticides or are forced to redesign their IPM programs. While IPM systems are important to many growers, the sensitivity to changes in the export market MRLs of U.S. IPM systems for two U.S. agricultural sectors in particular (nuts and hops) are described in greater detail in chapter 2 of this report.

Apples and Pears: The United States is one of the world's largest producers of apples and pears, with combined annual U.S. production valued at more than $3 billion.[9] Although the United States is a major supplier to a variety of export markets, U.S. producers have cited the loss of MRLs in the EU as contributing to a substantial decline in U.S. exports there. The EU, which had previously been the third-largest U.S. export market for apples, has notably reduced its imports of both pears and apples from the United States in recent years. Subsequently, apple and pear producers have shifted exports to less MRL-restrictive markets and have engaged in pre-export testing to limit the likelihood of MRL violations. Pre-export testing and monitoring MRLs in export markets may cost the industry up to $25 million annually.[10] Despite these measures, the U.S. apple and pear sectors have continued to experience multiple MRL violations in export markets, often due to missing MRLs.[11] These violations have raised costs due to destroyed shipments and increased inspections in some key markets.

Celery: The United States is one of the world's largest producers of celery, with a crop value of $475 million in 2019. Although the majority of U.S. production is consumed domestically, export markets are important to this industry. Japan is the second-largest export market (after Canada) for U.S. growers, worth $4.3 million in 2019. The U.S. industry experienced MRL violations on celery in Japan as a result of a reduction in Japan's temporary MRL on acephate on celery. These MRL violations resulted in enhanced inspection and port delays not only for the grower-shippers that inadvertently triggered the

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[8] EPA, "Integrated Pest Management (IPM) Principles," September 28, 2015; industry representative, interview by USITC staff, August 14, 2020; UC IPM, "What Is Integrated Pest Management (IPM)?" (accessed August 26, 2020).
[9] Apples constitute the vast majority of the total value of both crops. In 2019, the value of U.S. apple production was approximately $2.7 billion, while total U.S. pear production came to about $347 million. Combined, in 2019, these two products would constitute slightly in excess of $3 billion in U.S. production. In most years approximately half of U.S. pear production is exported; in 2019, for example, the U.S. pear sector exported approximately $163 million in production. By contrast, about one-third of U.S. apple production is exported in most years. USDA, NASS, "National Statistics for Apples," 2020; USDA, NASS, "National Statistics for Pears," 2019; Agricultural Marketing Resource Center, "Pears," July 2015.
[10] Industry representative, email message to USITC staff, September 25, 2020.
[11] An MRL violation occurs when a sample of a treated exported agricultural product is tested at port for presence of a pesticide residue and is found to have exceeded the existing MRL of that market. In some instances this can occur if a pesticide residue exceeds an established MRL, while in others this can occur if a market has not yet established an MRL for a pesticide and the MRL is set either to a low numerical default or no residue at all is permitted. MRL violations are described in further detail in chapter 1 of this report, and the implications of violations for U.S. crop exports are discussed in chapter 2.

violations, but for the entire U.S. celery industry. U.S. industry representatives are concerned that enhanced inspections could contribute to revenue losses from reduced demand and lower prices in Japan.

Pulses: The United States is the fifth-largest producer of chickpeas and the third-largest for lentils globally, producing nearly 660,000 tons of chickpeas and lentils combined, and exports are extremely important to this industry. Farmers of pulses (including lentil and chickpea farmers) in the United States rely on the active ingredient glyphosate for both weed control and as a desiccant to dry the crop before harvest. However, several export markets around the world are reviewing their pesticide and MRL policies regarding glyphosate. Industry representatives report that without the necessary MRLs for this key herbicide, particularly in the EU, the industry has few effective alternatives for these important steps in the growing process. The alternatives that do exist are reportedly less effective, contributing to income loss for growers through lower crop yields and quality. These commodities are frequently bulked and blended before export, and U.S. growers have noted that this practice has sharpened their concerns about being able to comply with low and missing MRLs in major export markets. Other industry representatives have noted that these impacts could intensify if other export markets choose to align their own import tolerances with those of the EU. [12]

Cranberries: U.S. cranberries are a specialty crop with a value of close to $500 million in 2019.[13] Since most global cranberry production occurs in the United States, the costs of missing MRLs or changes to MRLs for cranberries in foreign markets are largely borne by the U.S. cranberry sector. Several pests represent a substantial challenge to the U.S. cranberry industry, and the loss of MRLs in certain key markets, or missing MRLs, can limit the ability of cranberry growers to effectively respond to these pest pressures. For example, the recent non-renewal of chlorothalonil and chlorpyrifos in the EU and subsequent lowering of MRLs to the low default level is a concern for cranberry growers. Additionally, because cranberries are frequently processed before export and maintain a long shelf life, even the potential loss of a key MRL may reportedly lead farmers to proactively limit that pesticide's use, potentially affecting quality. A change in an MRL can undermine the marketability of a processed cranberry product well after the cranberry has been grown and harvested. Finally, the common practice of blending cranberries from various growers for export often contributes to an industry-wide effort to grow to the lowest MRL among key export markets. These issues can contribute to yield loss (when cranberry growers are unable to effectively control emerging pest pressures), higher operational costs, and lower expected revenue for U.S. growers.

Sweet Cherries: The United States is the second-largest global producer of sweet cherries (after Turkey), with 2019 U.S. production of over $650 million.[14] In contrast to some of the other temperate fruits described in this chapter (like cranberries and tart cherries), the vast majority of U.S. sweet cherries are exported in their fresh form to foreign markets. Because of this, MRL violations, which increase inspection and testing of future shipments as well as port delays, cost growers time and money and can erode the value of this fragile fruit. Additionally, growing pressures from pests, in particular the spotted wing drosophila (SWD), represents a rising challenge for the U.S. sweet cherry sector, as there are lower or missing MRLs for key insecticides used in addressing this fruit fly in certain key export markets,

[12] Industry representative, telephone interview by USITC staff, October 31, 2019.
[13] USDA, "Another Large U.S. Cranberry Crop Expected in 2019," 2019.
[14] USDA, NASS, "National Statistics for Cherries," 2020.

notably the EU. These low and missing MRLs can also contribute to increased costs for U.S. growers by forcing them to use more expensive insecticides, or face reduced yields—and subsequent revenue—if orchards are left untreated.

Tart Cherries: The United States grew $36 million of tart cherries in 2019 and is the fifth-largest producer of tart cherries in the world. Tart cherries are processed into a variety of high-value products before consumption, such as juice and dried cherries, making channel of trade issues problematic for this industry. As with U.S. sweet cherries, SWD has emerged as the industry's main pest issue over the last five years. Responding to this pest pressure results in higher production and export costs. MRL issues in foreign markets, particularly those in the EU, complicate responding to the pest pressure; one insecticide used in controlling SWD is not registered in the EU, while another insecticide that has the same MRL in both the EU and the United States reportedly costs twice as much. Overall, the lack of key insecticide MRLs for SWD in important export markets will likely contribute to yield loss, reductions in U.S. exports, and increased production costs for U.S. tart cherry growers.

Sweet Potatoes: The United States is the largest global exporter of sweet potatoes, with annual production valued at $588 million in 2019. Fungal diseases are a major concern for the U.S. sweet potato industry, as they reduce yields. While the U.S. industry relies heavily on cultural methods of control, such as crop rotation, fungicides provide additional options to control fungal disease. Export markets are an important source of revenue to the industry, providing up to six times the returns offered by the domestic market. However, low and missing MRLs in export markets, particularly the EU, offer growers a choice: either they can use less effective and potentially more expensive products to comply, which raises production costs and reduces yields, or they can use more effective pesticides, which results in the loss of export markets where such products are not permitted.

Edible Nuts: The United States is the world's leading producer of almonds and pistachios. These nuts are an important U.S. agricultural export, worth over $7 billion in 2019. U.S. edible nut industries have spent decades and millions of dollars battling a pest, the navel orangeworm, which spreads the fungus that produces aflatoxin, a fungal toxin dangerous to human health. To control navel orangeworm, the industry created an IPM program which includes the use of certain key pesticides. However, certain key U.S. export markets have begun to remove the registrations for some of these pesticides and lower the MRLs associated with those pesticides. There are concerns within the nut sectors that some important pesticides that farmers rely on may face increasing scrutiny in these markets and as a result may lose MRLs in those markets. The industries report that if those tools are lost, their IPM programs will be disrupted with little time to adjust, requiring them to choose between losing access to some of the most important export markets or facing potential increases in the prevalence of aflatoxin.

Hops: The U.S. hop industry, as one of only two major global producers, is highly dependent on exports and has invested considerable time and money to develop IPM systems to address threats to U.S. hop production from multiple pests and disease, including powdery mildew. However, since its IPM system depends on the availability of certain pesticides to function properly, the U.S. hop industry is increasingly concerned about the negative impacts that missing and low MRLs may have on their future production and profitability. Despite significant efforts by the U.S. industry to harmonize MRLs across markets, the EU has recently rejected the renewal of an important fungicide used against powdery mildew. The industry is apprehensive that the MRL for the relevant active ingredient may be lowered and it may not be able to secure an import tolerance for this fungicide, an outcome that could undermine U.S. production and exports. The slow pace of approval of new active ingredients in other export markets is also of concern.

Summary of Findings of Quantitative Economic Effects of MRLs

To assess the economic effects of missing or low MRLs on production, exports, farmer income, and prices, the Commission used a combination of gravity modeling, which is commonly used for estimating the effects of trade costs and trade facilitation measures, and other quantitative approaches. Using gravity modeling, chapter 3 presents a picture of global MRLs and how they compare across countries; estimates the relationships between MRLs and trade costs between countries; and quantifies the effects of MRLs on bilateral trade, prices, total imports, and total exports in many countries throughout the world. Chapter 4 examines the effects of MRLs on a more local level, focusing on individual farms and specific specialty crops (Costa Rican bananas and U.S. tart cherries) using a supply response analysis and a farm income statement analysis.

The Commission's model results show that globally, MRLs have affected bilateral trade in two ways: through the heterogeneity (divergence) in MRLs between importing and exporting countries and through the stringency of MRLs in the importing country. While the Commission's analysis shows that global trade patterns have been significantly affected by both MRL heterogeneity and stringency, the magnitudes and even directions of these effects differ across crops.

For most of the crops included in this analysis, including grains and oilseeds as well as a variety of fresh fruits and vegetables, the results of the Commission analysis show that MRL heterogeneity (divergence) deters bilateral trade. The Commission analysis also indicates that for a majority of the 30 largest crops (by trade) included in the analysis, stricter MRLs are associated with lower foreign imports.

The Commission used the estimated effects of MRL heterogeneity and stringency on bilateral trade to examine the global effects of changes in MRLs on prices and total imports and exports in different countries using a simulation gravity model. A hypothetical scenario in which the European Union (EU) would reduce all of its MRLs by 90 percent (roughly the magnitude of recent MRL changes) was simulated for three broad crop groups that have been described in case studies in both volumes of the report: tropical fruit, temperate fruit, and beans and peas. A reduction in EU MRLs was found to have potentially significant impacts on EU members and their closest trading partners. However, other countries less reliant on the EU market were able to mitigate the effects of the changes by shifting their trade patterns towards other partners. The Commission's results demonstrate that the MRL policies set within countries can have a potentially significant global impact. For the countries that export the most to the EU, the changes in prices can have real consequences for their consumers and producers. For other countries that are able to mitigate the changes, they can still result in significant alterations in trading patterns. For the crop groups examined in this report, the impacts for each market depend on the crop group. For tropical fruits, MRL heterogeneity had a trade-decreasing impact, while stringency had a trade-increasing impact. For both temperate fruit and fresh and dried beans and peas, increased MRL heterogeneity and stringency deter trade.

The simulation gravity model, while effective at measuring many of the effects of MRL changes on trade and prices, may not fully reflect some of the long-term impacts on production or income caused by reductions in exports to specific partners or price changes. The Commission therefore conducted additional analyses that supplement the economic models of trade and price effects of MRLs described above, including a supply response analysis and a farm income statement analysis for bananas produced in Costa Rica and tart cherries produced in the United States.

The supply response analysis, which considers producers' reaction to changes in global prices for their crops, indicates that this factor alone would likely result in relatively modest production impacts, particularly if these industries are able to adjust by shifting export destinations in a global market. However, if industries face severe trade impacts with key export destinations and have few alternative markets, price reductions and corresponding supply reductions are likely to be more substantial.

At the farm level, changes in MRLs in export markets (and MRL removals in particular) can have a range of effects that can impact a farm's production, costs, and profitability. When MRL removals occur in markets that farmers rely on for a large portion of their sales, they may change their production practices by switching to other pesticides, which are frequently more costly, less effective, or both. The analysis presented here indicates that this can decrease farmers' profitability. In the presentation of a more catastrophic scenario related to MRL removals, a lack of alternative pesticide products or limited IPM options made production infeasible. Even in cases where most of a farm's sales are made domestically, the decision to forego exports rather than implement these types of pesticide and farm practice changes can be the difference between profitability and unprofitability in years when domestic prices are low. Noncompliance with MRLs in foreign export markets presents a highly risky scenario that can substantially reduce a farmer's profitability, even if noncompliance occurs for only a small portion of their overall sales. Finally, there may be opportunities for well-positioned farms to improve their prices and operating income in cases where they are uniquely capable of meeting foreign MRLs.

Taken together, the results of the quantitative analyses in this report indicate that MRLs can have significant effects on the countries and farmers that most directly face those limits. This is particularly true for farmers that export intensively to particular markets and face limited pesticide alternatives. However, in many cases in which trade between specific markets is less intensive, the effects on countries overall may be less substantial.

Chapter 1 Introduction

Plant protection products, including pesticides, are important to agricultural producers working to ensure crop production for expanding populations. However, according to many industry stakeholders in the United States and worldwide, pesticide-related policies in some countries are creating significant challenges to agricultural trade.[15] Farmers are increasingly adjusting production practices in response to evolving policies and regulations governing the levels of pesticide residues on agricultural products. Governments regulate the level of pesticide residues permissible on crops by setting maximum residue levels (MRLs). Global differences in MRLs, including when MRLs are missing and low, as well as changing MRL policies in major agricultural export markets, can negatively affect farmers' costs as well as their ability to access export markets, which may affect their income.

Pesticides encompass a broad range of chemicals used to more efficiently produce and safeguard crops. These important tools help farmers prepare fields for planting, combat harmful pests and diseases during crop production, and protect harvested crops in storage and transit. Farmers worldwide depend on pesticides to obtain higher yields, minimize operating costs, and reduce postharvest losses. Strategic pesticide use is an integral part of modern farming, frequently as part of an integrated pest management (IPM) system.[16]

At the same time, there is global recognition about the importance of evaluating pesticides to ensure food safety. Regulators around the world generally seek to ensure that pesticides are available for use only after exposure to those pesticides is determined to have no or negligible adverse effects on human and animal health and the environment. As described in chapter 2 of *Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels, Volume 1* ("volume 1"), national regulatory bodies have established systems to evaluate the safety of pesticides, regulate pesticide usage, evaluate pesticide residue levels, and monitor compliance with these regulations. These regulations often evolve over time in response to further scientific research or changing attitudes about acceptable levels of risk.

Maximum Residue Levels (MRLs)

An MRL is the highest level of a given pesticide's residue that is legally tolerated for a given crop in a government's jurisdiction.[17] After evaluating a pesticide for efficacy and possible adverse effects, regulatory bodies generally set MRLs based on the exposure levels at which possible adverse effects

[15] The USITC received numerous submissions related to this factfinding report, including from U.S. industry groups, U.S. exporters, foreign governments, and foreign exporters. A full list can be found in appendix D of volume 1.
[16] IPM practices can include using biological controls (e.g., beneficial insects), chemical controls (pesticides), mechanical controls (e.g., use of row covers), and cultural controls (that is, controls related to cultivation—e.g., drainage and plant spacing).
[17] This MRL definition is provided in chapter 1 of volume 1. It is the definition used by Codex Alimentarius (an international standard-setting body discussed chapters 1 and 2 of volume 1) and major agricultural markets, including the United States and the European Union. EPA, "About Pesticide Tolerances," September 16, 2016; Codex, "Maximum Residue Limits (MRLs)," 2018; European Commission, "Maximum Residue Levels" (accessed February 20, 2020).

from these pesticides may occur. To establish a level of exposure unlikely to cause harm to humans, regulatory bodies evaluate actual pesticide residues in the context of dietary intake and other exposure, and establish MRLs on pesticide/crop combinations accordingly. MRLs allow regulatory bodies to ensure that both domestic and imported agricultural products are safe to consume and that growers have used pesticides correctly. Pesticides' negative effects on human health can be both acute and chronic, and they may have varying impacts on certain groups,[18] such as infants and children. These factors are taken into account during the risk assessments, which consider these human health impacts when evaluating pesticides and MRLs. MRLs are set at use patterns under Good Agricultural Practice (GAP) to ensure the protection of health and the environment.

Establishing MRLs, however, is a highly complex and costly endeavor. It involves collecting and evaluating large amounts of data in order to perform scientific risk assessments for each active ingredient/substance in a pesticide with respect to the specific crop to which it may be applied. In light of this, the Codex Alimentarius Commission, an international standard-setting body, establishes voluntary MRLs for global use. Governments can choose to adopt these international standard MRLs, in the limited cases where they exist, or to establish MRLs on their own.[19] From country to country, the established MRLs on the same pesticide/crop combinations frequently vary. Moreover, not all pesticide/crop combinations are covered by the MRLs established or adopted by regulators in their domestic markets; these never-established MRLs are sometimes referred to as "missing" MRLs.

Missing and Low MRLs

Stakeholders throughout the world's agricultural supply chains are concerned with the differences in MRLs across markets, including when they are missing or low. What constitutes a "missing" or "low" MRL is not strictly defined by the agricultural trade community. Chapter 1 of the first volume of this report includes an extensive discussion of missing and low MRLs. A summary of why MRLs might be considered missing and how stakeholders generally interpret a low MRL is provided in tables 1.2 and 1.3 of volume 1.

Agricultural exporters consider MRLs to be "missing" when a market to which they wish to export (import market) does not have an MRL for the pesticide/crop combination that they use or produce. There are several reasons why MRLs may be missing in a particular market: for example, a particular pesticide may not be registered in the market for use on any crops. Or if the pesticide is registered for use, it may not have established an MRL for a specific crop, or the market may not have adopted an existing Codex MRL for a pesticide/crop combination. A "low MRL" is generally understood to be a relative term, as agricultural exporters do not define it with a specific numerical pesticide residue level. Broadly, exporters consider an export market MRL to be low if it is lower than in their home market, lower relative to another export market, or lower relative to the Codex Alimentarius (Codex). Exporters may also consider an export market MRL to be low if it has been lowered from a previous level or set to

[18] Delaplane, "Pesticide Usage in the United States," March 1996; FAO, International Code of Conduct on the Distribution and Use of Pesticides, 2010.

[19] The Codex Alimentarius Commission (CAC) has established more than 4,800 Codex MRLs for a variety of specific pesticide/crop or pesticide/crop-grouping combinations. However, these represent a relatively limited number of MRLs relative to the number of MRLs needed by growers, given that each MRL represents a unique pesticide/crop combination.

a default, which for many markets is set at the analytical limit of quantification (also referred to as the lowest limit of analytical determination).

How MRLs Affect Trade

Differences in MRLs—including when MRLs are missing and low, as well as differences in MRL policies—have the potential to affect trade negatively. As described in detail in chapters 4, 5, and 6 of volume 1, these effects can ripple through the agricultural value chain and ultimately have consequences on production, prices, and farmer income. The impacts from missing or low MRLs can vary by country and may be particularly problematic for farmers exporting minor or specialty crops, which have fewer existing MRLs. Producers who face greater pest pressure may also be particularly affected by these factors.

Shifting MRL policies and differences in MRLs globally are increasingly affecting trade in a number of ways. Agricultural exporters may not be able to sell their crops to markets where an MRL is set lower than in their domestic market, particularly if the MRL is so low that it is difficult for producers to meet while still protecting their crops from harmful pests. A missing MRL for a pesticide/crop combination in a given market can mean the pesticide is automatically prohibited for use on a certain crop; the missing MRL can prevent exporters elsewhere that depend on use of that pesticide from shipping the crop to that market. Finally, shifting policies in importing markets complicate production and export decisions of farmers who rely on transparency and predictability in the trading system. Exporters and other stakeholders in the agricultural trade community are concerned about a number of aspects of these shifts, including the increased activity of government regulators in establishing their own MRL systems; variation in the international and country-specific frameworks guiding the regulation of certain pesticides and the establishment of MRLs; and the resulting differences in MRLs across markets.

There are several factors contributing to global differences in MRLs. The regulatory processes and practices for registering new pesticides and establishing MRLs vary from one market to the next—whether regarding data requirements, testing requirements, or methodological approaches—and can lead to different assessments of the hazards and risks associated with the same residues. In addition, scientific advances in detecting residue levels and in analyzing the effects of chemical substances on human health and the environment give regulators in some markets increasingly precise tools with which detect residue levels and to assess pesticides and set MRLs at levels that they consider safe. These changes affect both new and existing pesticides, as well as their associated MRLs. When registered pesticides and established MRLs undergo periodic reviews by regulatory bodies, such changes in technology and in regulators’ evaluation practices may contribute to the nonrenewal of certain pesticides and the subsequent reduction or elimination of their associated MRLs. Moreover, these changes in MRLs are sometimes implemented with brief transition periods, making it difficult for exporters to adapt their production practices in time.

Many of the costs and effects of divergent or low and missing MRLs are borne not only by growers, but also by other participants throughout the agricultural supply chain—such as processors, aggregators, exporters, retailers, and even pesticide manufacturers—in different ways.[20] These costs and effects confront growers in a broad range of countries, from upper-income countries like the United States to lower-middle-income countries in Africa, Asia-Pacific, and Latin America. Growers who attempt to comply with low or missing MRLs by reducing or eliminating the use of certain pesticides may incur costs in the form of production and yield losses or through the need to develop alternative pest management strategies that may be more costly. Growers are also generally reliant on pesticide manufacturers to register pesticides and to seek MRLs, but these costly and time-intensive processes entail a significant investment by these firms. Pesticide manufacturers can spend years and hundreds of millions of dollars researching and developing a single new pesticide, registering pesticides for use in multiple markets, and seeking MRLs for a variety of crops.[21] Growers constrained by missing or low MRLs and who have no access to alternative pesticides potentially may lose access to lucrative export markets.

Scope

The U.S. Trade Representative (USTR) asked the U.S. International Trade Commission (USITC or Commission) to conduct an investigation and provide a two-volume report on global economic impacts of missing and low pesticide maximum residue levels.[22] The USTR asked that the report include information and analysis about the impact of pesticide MRLs on farmers in countries representing a range of income classifications, including the United States. The USTR also stated that the report should cover the years 2016–19, but may, where appropriate, examine longer-term trends.

The first volume was delivered to USTR on June 30, 2020, and is available to the public on the Commission's website at https://www.usitc.gov/publications/332/pub5071.pdf. Volume 1 contains the following components, as described in the request letter:

1. An overview of the role of plant protection products and their MRLs in relation to global production, international trade, and food safety for consumers. Describe the current and expected challenges to global agricultural production, including the impact of evolving pest and diseases pressures in differing regions and climates.
2. A broad description of the approaches taken in setting national and international MRLs for crops. Describe the risk-based approach to setting MRLs in the context of agricultural trade, including the guidelines and principles of the Codex Alimentarius (Codex). Describe the procedures in the Codex for setting pesticide MRLs, including the role of the Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) Joint Meeting on Pesticide Residues (JMPR) in conducting risk assessments. Compare this risk-based

[20] USHIPPC, written submission to USITC, December 10, 2019, 4; NPC, written submission to USITC, December 10, 2019, 3; Wine Institute and CAWG, written submission to USITC, December 13, 2019, 4; CFFA, written submission to USITC, December 10, 2019, 2; Cranberry Institute, written submission to USITC, December 11, 2019, 1; NHC, written submission to USITC, December 13, 2019, 3; ABC, written submission to USITC, December 13, 2019, 2.
[21] Further information on the costs borne by pesticide manufacturers in researching and registering pesticides for crop use can be found in chapter 4 of volume 1.
[22] Appendix A contains a copy of the request letter, and appendix B contains the *Federal Register* notices associated with this investigation.

approach to a hazard-based approach. Describe U.S. efforts to advance the use of lower-risk pesticides globally.

3. A description of how MRLs for plant protection products are developed and administered in major markets for U.S. agricultural exports. Describe the specific regulations, processes, practices, and timelines in these major markets for establishing, modifying, and administering MRLs. Describe specific MRL enforcement practices and processes, including practices and procedures for addressing noncompliant imported plant products. Provide examples of how Codex MRLs are adopted into national legislation or regulation. Identify trade-facilitative practices and processes.
4. A description of challenges and concerns faced by exporting countries in meeting importing country pesticide MRLs, such as when MRLs are missing or low. Explain the reasons for missing and low MRLs.
5. Through case studies, describe the costs and effects of MRL compliance and noncompliance for producers in countries representing a range of income classifications, such as uncertainty in planting decisions, segregation of products, crop protection costs, yield implications, storage issues, product losses, and consequences of MRL violations. Include information on costs of adopting new plant protection products or those related to establishing, modifying, or testing for new or existing MRLs in export markets. To the extent possible, include effects on producers in countries with tropical climates where products are subject to high levels of pest and disease pressure.
6. A review of the economic literature that assesses both qualitatively and quantitatively how missing and low MRLs affect countries representing a range of income classifications, particularly low-income countries, with regard to production, exports, farmer income, and prices.

Volume 2 of this report (the present report) provides the following components as described in the request letter. The USTR requested that this second volume be delivered by January 31, 2021, and contain:

7. Case studies, which describe the costs and effects of MRL compliance and noncompliance for U.S. producers, such as uncertainty in planting decisions, segregation of products, crop protection costs, yield implications, storage issues, product losses, and consequences of MRL violations. They are to include information on costs of adopting new plant protection products or those related to establishing, modifying, or testing for new or existing MRLs in export markets. To the extent possible, include effects on U.S. producers of specialty crops.
8. To the extent possible, quantitative and qualitative assessments that discuss how missing and low MRLs affect production, exports, farmer income, and prices, both on the national level and, to the extent possible, for small and medium-sized farms.

In response to the USTR’s request, this volume focuses on the costs and effects of MRL compliance and noncompliance for U.S. producers and also provides quantitative and qualitative assessments of the effects of missing and low MRLs. The scope of the report is limited to pesticide and MRL policies related to crops and plant protection products.

Organization

This second volume of the report is divided into four chapters. After introducing the scope of this volume of the report, the first chapter provides an abbreviated overview of concepts and technical terms related to pesticide and MRL policies, as well as an overview of U.S. agricultural exports to major export markets. It summarizes some of the MRL-related challenges that U.S. growers have identified in their efforts to comply with MRLs, including the associated impacts on their carefully crafted domestic IPM systems, as well as the consequences they face in cases of noncompliance. The second chapter presents a series of case studies that depict the costs and effects of MRL compliance and noncompliance on U.S. producers of a variety of specialty crops produced across the United States. It includes case studies on several U.S. specialty crops, including fruits, vegetables, nuts, and hops. The third and fourth chapters present quantitative and qualitative analyses that estimate the economic effects of missing and low MRLs on production, exports, farmer income, and prices on a global level as well as on a farm level for specific industries.

Approach

To prepare this report, Commission staff conducted research and interviewed government officials, grower organizations, research and extension service groups, pesticide manufacturers and associations, and industry representatives, including farmers, exporters, importers, and retailers. In addition, the Commission obtained information at its public hearing held on October 29, 2019, as well as from briefs and other written submissions received in connection with the hearing and in response to the Commission's notice of investigation published in the *Federal Register* on September 27, 2019.[23]

The quantitative estimates of how missing and low MRLs affect national and farm-level production, exports, farmer income, and prices are generated with the use of several economic models and approaches. The Commission used an empirical gravity model and a simulation gravity model to evaluate how current MRLs impact global trade and how trade relationships would change under hypothetical changes to MRL rules. The Commission also used additional quantitative approaches that incorporated both the price changes predicted in the gravity model and other price simulations to evaluate impacts on production and farm income on a narrower, crop-specific basis. Table 1.1 summarizes all four quantitative approaches used by the Commission in this volume and describes the crop and country coverage of each analytical approach.

[23] See appendix C for the calendar of witnesses at the USITC public hearing, and appendix D for summaries of views of interested parties.

Table 1.1 Summary of approaches for quantifying economic effects of MRLs

Chapter	Analytical approach	Coverage	MRL	Crop level	Measures
3	Empirical gravity model	*Global*	MRL indices	*Crop-specific* (101 crops)	Observed direct impact of MRL stringency and heterogeneity on bilateral trade
3	Simulation gravity model	*Global*	MRL indices	*Aggregate crop level* Tropical fruit Temperate fruit Beans and peas	Impact of 90 percent reduction of EU MRLs on global trade (exports and imports), farm gate prices, consumer prices, and terms of trade
4	Supply response analysis	*National* Costa Rica United States	Crop-specific	*Crop-specific* Bananas Tart cherries	Producer supply response (production change) from MRL removal or reduction in export market
4	Farm income statement analysis	*Subnational* Costa Rica United States	Crop-specific	*Crop-specific* Bananas Tart cherries	Farm income statement effects of a variety of cost, yield, price, and shipment changes associated with MRL reductions or removals in key export markets

Source: Compiled by USITC.

The empirical gravity model presented in chapter 3 covers bilateral trade flows on a crop-specific basis. First, trade effects were estimated for over 100 crops. These observed direct trade effects were then incorporated into a simulation gravity model to analyze overall national trade and price effects related to specific changes in MRLs for more than 30 countries. Given the high number of individual crops considered for the empirical analysis and the complexity of the gravity model, the simulation gravity model analysis is conducted on a smaller number of crop groups. The simulation gravity model in chapter 3 describes the effect of a reduction in EU MRLs on three aggregate crop groups—tropical fruit, temperate fruit, and fresh and dried beans and peas.

The broad crop groupings used in the simulation gravity model contain products detailed in several case studies, covering both U.S. producers and producers in a broad range of countries at varying levels of economic development. For example, in volume 1 of the report, case studies detailing the costs and effects of MRLs were given for foreign producers of tropical fruits such as bananas, coffee, and mangos. In both volumes of the report, case studies detailing the costs and effects of MRLs on temperate fruits are available for foreign and U.S. producers of crops including table grapes, apples, pears, tart cherries, and sweet cherries. The last major crop group, which includes both fresh and dried beans and peas, is covered in both the fresh French bean case study included in volume 1 as well the U.S. pea and lentil case study included in this volume.

In order to assess the effects of MRLs at the national and farm level, particularly production and farm income effects, this report focuses on two specialty crop industries. The complementary quantitative analyses in chapter 4 focus on one foreign agricultural industry (bananas produced in Costa Rica) and one U.S. domestic agricultural industry (tart cherries produced in the United States). The analysis in this chapter is drawn from information provided in case studies in volumes 1 and 2 of this report as well as the gravity model results of chapter 3, which provide insight into the specific and the broader effects of MRLs on agricultural industries, respectively.

This report focuses primarily on the years 2016–19, the latest three years for which data are available. However, it also examines longer-term trends where appropriate. For example, the gravity model analysis relied on MRL data sourced from the Homologa Historical Dataset from Lexagri. A time series panel of MRL data from this dataset spanning from 2005 to 2016 for over 50 countries was used to develop the underlying foundation for the gravity model framework, the MRL indices. Additionally, some of the case studies in chapter 2 of this report examine changes in MRL practices in key export markets before the 2016–19 period, when relevant for the crop sectors studied.

Overview of Key Terms and Concepts

As discussed extensively in the first volume of this report, establishing MRLs is a complex process taken on by regulatory authorities around the world. Typically, regulatory authorities evaluate the chemical compounds in pesticides and assess the health and environmental effects of pesticide residues before establishing MRLs for each pesticide/crop combination. This complex process involves collecting and analyzing large amounts of detailed scientific data on the active substances in pesticides, pesticide usage, the residues of pesticides left in or on crops and the effect of such residues on human health and the environment.

The following technical terms and concepts associated with regulating pesticide use and establishing MRLs are used throughout this report. Additional terms and concepts related to pesticide registration and MRL establishment are covered in further detail in chapter 1 of the first volume.

Pesticide: For purposes of this report, pesticides are defined as plant protection products containing chemical compounds that act to control the target pest (e.g., insects and diseases) and include fungicides, herbicides, rodenticides, and insecticides. The term “pesticide” can refer to the active substance or a marketed product that can include a combination of active substances in addition to inert ingredients.[24]

Active Substances: Active substances (also called active ingredients) are the chemicals in the pesticide that act to control the target pest or disease. Active substances exclude solvents, preservatives, or other adjuvants that modulate the performance or application of the pesticide.[25]

Specialty crop: Defined in the United States as “fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops (including floriculture).” These crops include plants that are “cultivated or managed and used by people for food, medicinal purposes, and/or aesthetic gratification.”[26]

Minor crop: Although there is no standard definition of a minor crop, they are often high-value specialty crops with relatively low production levels.[27]

[24] EPA, “Basic Information about Pesticide Ingredients,” July 15, 2019. Inert ingredients may or may not be toxic. Inert ingredients are defined by the U.S. Environmental Protection Agency (EPA) as any component of a pesticide formulation that is not an active substance. These may include solvents, preservatives, or other adjuvants that modulate or enhance the performance or application of the pesticide.
[25] EPA, “Basic Information about Pesticide Ingredients,” July 15, 2019.
[26] Specialty Crop Competitiveness Act of 2004, Pub. L. No. 108-465, § 3 (2004); USDA AMS, “What Is a Specialty Crop?” (accessed February 25, 2020).
[27] The EPA defines minor use crops as those having less than 300,000 acres of growing area. OECD, *Guidance Document on Regulatory Incentives for the Registration of Pesticide Minor Uses*, June 23, 2011, 12; EPA, “Minor Uses and Grower Resources,” August 2, 2019; OECD, “Minor Uses of Pesticides,” 2019.

Maximum Residue Levels: The Codex Alimentarius Commission (CAC), an international organization that sets MRLs for crops, defines MRLs as "the maximum concentration of a pesticide residue recommended to be legally permitted on or in food commodities and animal feeds. MRLs are based on Good Agricultural Practice (GAP) data and foods derived from commodities that comply with the respective MRLs are intended to be toxicologically acceptable."[28] According to the Food and Agriculture Organization of the United Nations (FAO), "GAP includes the nationally authorized safe uses of pesticides under actual conditions necessary for effective and reliable pest control."[29]

An MRL is the highest level of a given pesticide's residue that is legally tolerated for a given crop in a government's jurisdiction. Governments establish MRLs to ensure that any pesticide residues left on food crops are at levels that are safe for human consumption and in some cases ensure they are not harmful to the environment. MRLs apply to a specific pesticide/crop combination and are typically measured in terms of milligrams per kilogram (mg/kg) or parts per million (ppm). In some markets (such as the United States), MRLs may also be referred to as "tolerances."

Pesticide Registration and MRL Establishment: The establishment of an MRL typically hinges upon the registration of an active substance or pesticide for domestic use, with the exception of import tolerances, which are described in greater detail below. An MRL may be established for a particular market only if the active substance (or pesticide) is first registered in that market; if a pesticide is not registered in a market, MRLs cannot be established. While pesticide registration allows use of the pesticide in the relevant jurisdiction, an MRL is still needed to define the maximum concentration of a pesticide residue legally permitted on or in a crop.

MRLs based on pesticide registration for domestic use in a specific market reflect the growing conditions, pest and disease pressures, and crops grown in that market and generally apply to both imported and domestic products. MRLs for pesticides that are not registered in a particular market may be considered missing in that market.

Import Tolerance: An import tolerance is used by exporters to fill a "missing" MRL that does not exist for their particular pesticide/crop combination in the market to which a crop is exported or where the MRL exists but is lower than that of the producing country. An import tolerance may be set by an importing market's government because the pesticide is not registered in the domestic market but is used by exporters to that market. In other cases, an import tolerance might be sought by exporters because, while the pesticide is registered for use in the import market, the existing MRL is insufficient to meet an exporter's use pattern. In those cases, the existing MRL might be raised.

Default MRLs: When a country has not established an MRL for a specific pesticide/crop combination, or it has been revoked, regulators may elect to apply a "default" MRL to imported crops treated with this pesticide. Regulators may choose among several options in determining the default they will apply, including deferring to a Codex MRL or another country's MRL, or using a numerical default level (a

[28] Codex, "Codex Maximum Residue Limits for Pesticides" (accessed March 2, 2020).
[29] Further, according to the FAO, GAP "encompasses a range of levels of pesticide applications up to the highest authorized use, applied in a manner which leaves a residue which is the smallest amount practicable. Authorized safe uses are determined at the national level and include nationally registered or recommended uses, which take into account public and occupational health and environmental safety considerations. Actual conditions include any stage in the production, storage, transport, distribution and processing of food commodities and animal feed." Codex, "Codex Maximum Residue Limits for Pesticides" (accessed March 2, 2020).

preset level not determined through an evaluation of the pesticide residue). Some markets elect to adopt a combination of these types of default options for different pesticide/crop combinations.

For markets that elect to use their own numerical default, such as South Korea and the EU, the default MRL can be set near the "lowest limit of analytical determination." Many of these markets use a numerical level of 0.01 ppm for their "limit of determination/quantification" default. However, while numerical defaults for MRLs are typically intended to be very low, they vary by market, ranging from a low of 0.01 ppm to a high of 0.1 ppm.[30] In some instances a numerical default MRL can effectively block market access.

In the absence of a default, some markets may have zero tolerance for residues. That is, if no MRL has been set for a particular pesticide, then a crop with any detectable residue of that pesticide is not permitted. This practice effectively blocks market access for imported crops treated by a pesticide for which an MRL does not exist in the import market.

Integrated Pest Management (IPM): An IPM program (or system) is a pest management approach that focuses on long-term prevention of pests in crops using a variety of practices. This can include habitat manipulation, modification of cultural practices, use of resistant varieties of crops, and biological controls, in addition to pesticide use. An IPM program is designed to minimize costs and negative impacts of pests and diseases while maximizing crop yield and quality.

Cultural Controls: Cultural controls are farming practices that are designed to reduce or eliminate unwanted pest populations and disease pressures. Cultural controls are nonchemical methods of pest and disease control. They can range from simple concepts—such as adjusting planting dates, removing infected plant material from fields, or rotating crops to avoid pest infestations—to more complex practices that disrupt insect life cycles, including the use of beneficial insects to control pests.[31]

Mode of Action: The mode of action is the process through which a pesticide works on a target pest. Using pesticides with identical modes of action can contribute to pesticide resistance.

Overview of U.S. Exports of Crop Products to Major Markets

As was described in the third chapter of volume 1, many markets—including major U.S. agricultural export markets—have moved away from deferring to Codex MRLs and have instead developed "positive list" systems, in which governments establish their own independent lists of MRLs for pesticide/crop combinations. Canada, China, the EU, Japan, South Korea, and Taiwan, are among the major markets for

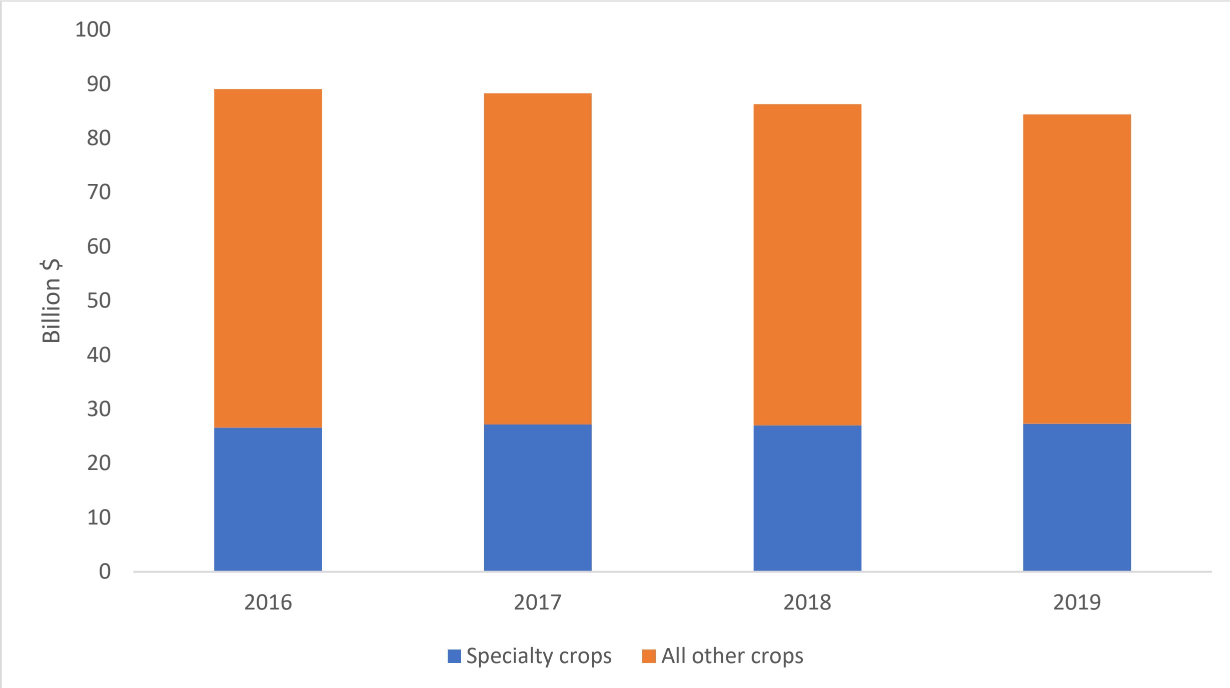
[30] The "lowest limit of analytical determination" is also referred to as "the limit of determination" and is often used synonymously with the "the limit of quantification." These terms refer to the lowest amount of a substance that is quantifiable, within a margin of error. The "limit/level of detection" is sometimes used instead of these terms, although this term is defined as the lowest quantity at which a substance can be detected, even if the amount present cannot be quantified. Ecorys, *Study Supporting the REFIT Evaluation*, October 10, 2018, 85; European Commission, "How Are EU MRLs Set?" (accessed February 20, 2020); industry representatives, interview by USITC staff, March 5, 2020; IUPAC, *Compendium of Chemical Terminology* (accessed March 26, 2020).
[31] University of California Agriculture and Natural Resource IPM Program, "What Is Integrated Pest Management?" (accessed August 28, 2020); Ferr, "Cultural Control" (accessed August 28, 2020).

U.S. crop exports that have developed positive list systems (the United States also maintains a positive list system). These systems include MRL regulations, requirements, practices, processes, and timelines for the approval and registration of active substances used in pesticides and for establishing MRLs and import tolerances. Each of these markets' systems is complex, and though they have much in common, none is identical to or completely harmonized with the others.

This volume includes case studies that illustrate the costs and effects experienced by U.S. producers of specialty crops in complying with MRLs established by several of these markets. Specialty crops typically constitute nearly one-third of the annual value of U.S. crop exports (figure 1.1),[32] and MRL regulatory issues can be particularly problematic for these crops. Such crops generally have fewer existing MRLs due in part to the small size of the industries. The specific case studies were chosen based on industry feedback, recent MRL changes, and an interest in geographic and crop diversity (including both highly perishable crops and crops with longer shelf lives).

[32] Agricultural export data in this report are based on domestic export values. U.S. agricultural exports include edible crops and crop-based products as well as animal and inedible products. Edible crops and crop-based products, which are highlighted in this report, include fresh, frozen, and prepared products of vegetables, fruits, and grain. Animal and inedible products include edible meat and dairy products, including beef, pork, poultry, and fish, and inedible products such as tobacco, hides and skins, and cotton; these products are not the focus of this report. For purposes of this report, agricultural crops were categorized based on USITC commodity digests. These USITC digest sectors encompass a number of related 8-digit subheadings in the *Harmonized Tariff Schedule of the United States* (HTS), which classifies tradable goods. The sectors are listed and defined in USITC, "Frequently Asked Questions," *Shifts in U.S. Merchandise Trade 2015*, September 2016. In this report, crop exports refer to edible crops and crop-based products included in agricultural products sectors (AG) digests AG017 to AG042. Specialty crops include products in AG digests 017 to 029 and 037 to 038, and include fruits, vegetables, nuts, cocoa, spices, coffee, and tea. Other crop products are captured in AG digests 030 to 036 and 039 to 042, and include products such as alcoholic beverages, grains, oilseeds, animal or vegetable fats and oils, and processed products such as pasta, baked goods, infant formula, sauces, soups, and condiments. USITC DataWeb/USDOC (accessed January 24, 2020). For further information on commodity digests, see https://www.usitc.gov/data/index.htm.

Figure 1.1 U.S. crop exports: Specialty crops and other edible crop products, 2016–19 (billion dollars)



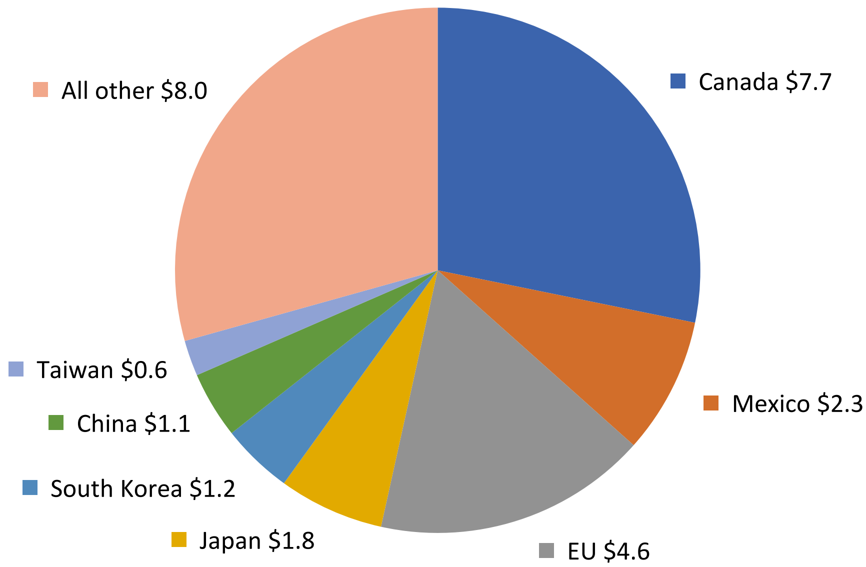
Source: USITC, *Shifts in U.S. Merchandise Trade Dataset*. U.S. crop exports represent agricultural (AG) products sectors in USITC digests 017–042.
Note: Corresponds to appendix table H.1.

Overview of MRL Trends in Major U.S. Export Markets

The case studies presented in chapter 2 of this volume of the report identify and describe the impacts of MRL-related changes in several major U.S. export markets on U.S. exports and U.S. production. Some notable features of these markets' pesticide and MRL regulations are summarized below;[33] see a full description of the policies and regulatory structures of these (and other) key markets in chapter 3 of the first volume of this report. These markets are often the largest export destinations for U.S. exports of particular specialty crops (figure 1.2). As a result, MRL changes in these markets can be particularly impactful for U.S. specialty crop growers.

[33] Although Mexico is the United States' second-largest export market for agricultural products, U.S. exporters of specialty crops did not identify challenges with Mexican MRLs. Reportedly, Mexico often harmonizes its MRLs with U.S. MRLs, and very few challenges with Mexican MRL regulatory process were identified or reported by industry stakeholders. Multiple industry representatives noted that Mexico appears to accept U.S. MRLs on imported foods from the United States, meaning that bilateral trade disruptions between the United States and Mexico over MRLs would be unlikely and that this unofficial arrangement facilitates bilateral trade. Cranberry Institute, written submission to USITC, December 11, 2019, 9; ABC, written submission to USITC, December 13, 2019, 7; CFFA, written submission to USITC, December 12, 2019, 3; APC, written submission to USITC, December 6, 2019, 2; U.S. government official, interview by USITC staff, December 9, 2019.

Figure 1.2 U.S. specialty crop exports by major export market, 2019 (billion dollars)



Source: USITC, *Shifts in U.S. Merchandise Trade Dataset*. U.S. specialty crop exports represent agricultural (AG) products sectors in USITC digests 017 to 029 and 037 to 038, and include fruits, vegetables, nuts, cocoa, spices, coffee, and tea.
Note: Corresponds to appendix table H.2.

Canada

Canada is the United States' largest agricultural export destination, with an average of $15.1 billion in crop exports during 2016–19. During this period, an average of $7.7 billion of these U.S. exports were specialty crops. Canada's MRL system has operated in its current framework for more than a decade and is characterized by extensive collaboration with the United States due to longstanding trade ties. Industry representatives have commented positively on the straightforward nature of Canada's MRL-setting process. This is reportedly a result of a series of regulatory reforms which enabled a faster approval process for establishing MRLs in Canada, with a consequent rise in the number of MRLs. In addition, industry representatives have praised Canada's default MRL, which is 0.1 ppm, as facilitating agricultural trade flows with Canada. In comparison, most other markets have a numerical default of 0.01 ppm, or do not set any default level (effectively prohibiting imports with residues of the pesticide involved).

China

China is the United States' third-largest agricultural export destination, with an average of $11.7 billion in annual crop exports during 2016–19.[34] During this period, an average of $999 million of these U.S. exports were specialty crops. China's current MRL system is relatively new, and large tranches of new

[34] USITC DataWeb/USDOC (accessed January 24, 2020).

MRLs have been established by the relevant Chinese regulatory agencies in the past three years.[35] The Chinese government has indicated an interest in setting up to 10,000 MRLs by the end of 2020.[36] Industry representatives, however, have expressed concern about a lack of transparency in the regulatory approval process for MRLs in China and about requirements to conduct pesticide residue trials in China rather than in the producing market.[37] U.S. growers note in particular that it is unclear to what extent China defers to Codex MRLs in the absence of existing Chinese MRLs, and multiple industry representatives have also asserted that it is not possible to secure an import tolerance in China.[38] This can be particularly problematic for certain specialty crops grown in the United States that are not grown in China (such as cranberries), as the lack of data on domestic production with particular pesticides in China inhibits the ability to set an MRL.[39]

European Union

The European Union (EU) is the United States' fourth-largest agricultural export destination, with an average of $9.8 billion in annual crop exports during 2016–19.[40] During this period, an average of $4.4 billion of these U.S. exports were specialty crops. The EU is currently in the midst of a large-scale review of active substances, and numerous industry representatives have described concerns that many critical MRLs have been lowered, sometimes to default levels, as a result of this review process.[41] Industry representatives have also expressed concerns that some existing import tolerances may also be revoked, or new import tolerances will not be granted, in part because of the EU's active substance review process.[42]

Given the large size of the EU market, EU MRL changes can have a substantial impact on agricultural production and trade globally. Because it can be difficult to produce agricultural crops to meet different pesticide residue limits in different markets, EU MRLs affect the production decisions of numerous exporting producers for whom the EU is a large export market. U.S. producers for multiple agricultural commodities addressed in chapter 2 of this report noted that changes to EU MRLs can have a substantial impact on exports around the world due to difficulty segregating crops before export.[43]

In addition, some countries either formally or informally defer to EU MRLs in the absence of their own domestic MRLs. This amplifies the importance of EU pesticide and MRL policy decisions as EU policies

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[35] Fang, "Pesticide Dietary/Residue Risk Assessment and MRL Development in China," September 11, 2019.
[36] Government of China, GB 2763-2019, August 2019; USDA, FAS, *China—People's Republic of: National Food Safety Standard*, November 18, 2019, 2.
[37] Fang, "Overview of China's New Pesticide Regulations," October 9, 2019.
[38] NPC, written submission to USITC, December 13, 2019, 9; CCB, written submission to USITC, December 11, 2019, 5; industry representative, interview by USITC staff, March 5, 2020.
[39] Cranberry Institute, written submission to USITC, December 11, 2019, 8.
[40] USITC DataWeb/USDOC (accessed January 24, 2020).
[41] Please see page 118 of volume 1 of this report. European Commission, "Renewal of Approval" (accessed February 20, 2020).
[42] Foreign government representative, interview by USITC staff, October 22, 2019; industry representative, interview by USITC staff, February 13, 2020.
[43] Industry representative, interview by USITC staff, June 23, 2020; industry representative, interview by USITC staff, June 24, 2020; industry representative, interview by USITC staff, June 25, 2020; industry representative, interview by USITC staff, June 26, 2020; industry representative, interview by USITC staff, July 9, 2020.

and preferences impact other markets in a "ripple effect."[44] This effect is of particular concern to U.S. producers because the EU has recently declined to renew several existing active substances used by multiple U.S. crop sectors. According to U.S. industry representatives, this has created uncertainty, potentially increasing costs for growers.

Japan

Japan is the United States' fifth-largest agricultural export destination, with an average of $6.8 billion in annual crop exports during 2016–19.[45] During this period, an average of $1.8 billion of these U.S. exports were specialty crops. Japan has maintained a positive list system since 2006, and industry representatives noted that Japan's work with domestic and foreign industry representatives to determine MRLs for a variety of pesticide/crop combinations helps facilitate trade. Several industry representatives identified Japan's practice of initiating evaluations of pesticides for MRLs concurrently with the manufacturer's home country evaluation as an additional trade-facilitative practice in the MRL-setting process for imported products.[46] In the event of an MRL violation, however, Japan reportedly conducts frequent testing for longer time periods than other markets, and several industry representatives have noted that MRL violations in Japan have resulted in negative trade impacts on an entire sector.[47]

South Korea

South Korea is the United States' sixth-largest agricultural export destination, with an average of $3.7 billion in annual crop exports during 2016–19.[48] During this period, an average of $1.2 billion of these U.S. exports were specialty crops. South Korea transitioned to a positive list system in two phases, in 2016 and 2019. South Korea conducted extensive outreach to industry representatives when setting its new MRLs and incorporated some Codex MRLs into its domestic regulations.[49] Some industry representatives, however, have expressed concern that many of the temporary MRLs set up to facilitate the transition to the positive list system (which will expire in December 2021) may not be made permanent, and reported that this could result in trade disruptions if these MRLs are automatically set to South Korea's default of 0.01 ppm when the transition period expires.[50] While many of the major crops are expected to receive the necessary import tolerances before the transition to default MRLs, one industry representative expressed concern that minor or specialty crops may not be able to secure

[44] NPC, written submission to USITC, December 10, 2019, 5; CCQC, written submission to USITC, December 10, 2019, 4; U.S. Grains Council, NCGA, and MAIZALL, written submission to USITC, December 13, 2019, 21; USHIPPC, written submission to the USITC, December 13, 2019, 5.
[45] USITC DataWeb/USDOC (accessed January 24, 2020).
[46] Cranberry Institute, written submission to USITC, December 11, 2019, 7; USHIPPC, written submission to USITC, December 10, 2019, 6.
[47] Chow, "U.S. Celery Export Violations Found in Japan," August 6, 2019; APC, written submission to USITC, December 6, 2019, 2; U.S. Grains Council, NCGA, and MAIZALL, written submission to USITC, December 13, 2019, 19.
[48] USITC DataWeb/USDOC (accessed January 24, 2020).
[49] Lantz, "The Coming MRL Challenge in Korea," July 2016; USDA, FAS, *Republic of Korea: Implementation of Positive List System for Maximum Residue Limits*, November 29, 2018, 2; NABC, written submission to USITC, December 9, 2019, 3.
[50] Industry representative, interview by USITC staff, December 12, 2019; CCB, written submission to USITC, December 11, 2019, 4.

MRLs due to the high cost of the testing and field trials necessary to receive active substance and MRL designations for the South Korean market.[51] Additionally, several major U.S. growers have noted that in instances of noncompliance with South Korean MRLs, the subsequent increased testing can contribute to declines in revenue and market access in South Korea.[52]

Taiwan

Taiwan is the United States' eighth-largest agricultural export destination, with an average of $2.3 billion in annual crop exports during 2016–19.[53] During this period, an average of $572 million of these U.S. exports were specialty crops. Taiwan began to develop its positive list system in 1999–2000.[54] Similar to Australia and the United States (among other markets), Taiwan does not have a numerical default provided in its MRL regulations (such as Canada's 0.1 ppm or the 0.01 ppm set by Japan and the EU), though in practice it appears to frequently set MRLs to a 0.01 ppm default.[55] Industry representatives have praised the collaborative framework set up by Taiwan's MRL regulatory authorities.[56] However, industry representatives indicate that the process for receiving import tolerances in Taiwan appears to be slower now than it was during 2000–10; one report noted that setting import tolerances can take "several years" in certain circumstances.[57] Additionally, industry representatives have noted that violations, and subsequent increased testing and port delays, can depress revenue for U.S. growers.[58]

Costs and Effects for U.S. Producers Related to Missing, Low, and Divergent MRLs

U.S. crop growers identified several challenges with export market MRLs, including compliance with missing, low, and divergent foreign market MRLs; penalties for noncompliance and MRL exceedances in export markets; pest resistance challenges that emerge when growers choose to comply with changes in export market MRLs; and the pressure that compliance with these changes can exert on U.S. crop growers' IPM systems. After an MRL violation has been detected in a shipment in an export market port, that market's regulatory authority may respond in different ways for future shipments. For example, in certain instances, shipments from that individual supplier may be subject to increased testing, while in other circumstances shipments of that product from any supplier from that market could be subject to increased testing. In other instances, an MRL violation with respect to one supplier may prompt imports of that product from other suppliers to become subject to additional MRL compliance testing.

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[51] Industry representative, interview by USITC staff, December 12, 2019.
[52] Industry representative, interview by USITC staff, June 26, 2020.
[53] USITC DataWeb/USDOC (accessed January 24, 2020).
[54] Yeung et al., *Declining International Cooperation on Pesticide Regulation*, 2017, 4; Government of Taiwan, Food and Drug Administration, "Pesticide Residue Limits in Foods," November 6, 2019.
[55] Yeung et al., *Declining International Cooperation on Pesticide Regulation*, 2017, 4; Government of Taiwan, Food and Drug Administration, "Pesticide Residue Limits in Foods," November 6, 2019.
[56] TECRO, written submission to USITC, December 13, 2019, 38–39; NABC, written submission to USITC, December 9, 2019, 5; CLA and CLI, "Taiwan MRLs + Import Tolerances," 2017.
[57] NPC, written submission to USITC, December 10, 2019, 8; APEC, *APEC Compendium of Government Administration in Setting Maximum Residue Limits for Pesticides*, June 2019, 26–29; CLA and CLI, "Taiwan MRLs + Import Tolerances," 2017.
[58] Industry representative, interview by USITC staff, June 26, 2020.

Cost of Compliance with Missing, Low, and Divergent MRLs

Compliance with missing, low, and divergent MRLs impacts producers and other stakeholders in the agricultural supply chain. U.S. crop producers noted several challenges associated with complying with such MRLs in important U.S. export markets. These challenges include the loss of active substances used to control pest pressures, with limited alternatives to address pest challenges (which can often be more expensive or less effective); an inability to secure MRLs or import tolerances in key markets due to unclear regulations and lack of regulatory predictability; and difficulty securing MRLs or import tolerances for smaller specialty crops that may be grown only in a few markets. Additionally, U.S. growers have frequently noted that they have had to grow their crops to the lowest MRL of a major foreign export market for all export market destinations when the crop is blended or cannot be easily segregated. Finally, U.S. growers noted that channels of trade issues (where MRLs for a processed agricultural commodity with a longer shelf life may be changed) and pre-export testing of crops contribute to increased operational costs of production and add further uncertainty to the export of U.S. crops.

Costs of Noncompliance

MRL violations can impact producers along the agricultural supply chain and can extend to other agricultural sectors. Industry representatives from multiple U.S. specialty crop sectors have noted not only lost sales resulting from an MRL-exceeding shipment to an export market, but also the increased ongoing costs of additional testing. This increased testing often contributes to port delays, which can limit expected sales to consumers. Additionally, noncompliance has led to lost market access for some U.S. crop-producing sectors, with exports subsequently sent to other export markets or redirected to the U.S. domestic market. Industry representatives have also noted that in some instances, firms have chosen to forego exports to key markets out of a concern over even potential noncompliance. Firms indicate that they often incur higher operational costs as well as decreased expected profit from sales due to such additional testing and/or redirection to other markets.

Pest Pressure and Integrated Pest Management

IPM systems typically involve the judicious use of pesticides in combination with a variety of other pest management strategies such as pest identification, monitoring, and the use of cultural controls in an effort to create a balanced system that minimizes costs and negative impacts of pests while maximizing crop yield and quality.[59] In contrast to traditional pest control, which involves the routine use of pesticides, IPM strategies focus on pest prevention and limited pesticide application, particularly if effective non-chemical methods are available. Pest pressures can threaten the viability of individual

[59] IPM practices focus on long-term prevention of pests using habitat manipulation, modification of cultural practices, the use of resistant varieties, and biological controls in addition to chemical controls. These programs use information about pest life cycles and how they interact with the environment to manage pest damage while minimizing production costs to farmers and impact on the environment and human and animal health. Biological controls are the use of natural enemies of a given pest, and cultural controls are grower practices that reduce pest establishment, reproduction, dispersal, and survival. UC IPM, "What Is Integrated Pest Management (IPM)?" (accessed August 26, 2020); EPA, *Introduction to Integrated Pest Management* (accessed August 11, 2020); EPA, "Integrated Pest Management (IPM) Principles," September 28, 2015.

farms or entire agricultural sectors. U.S. industries reported that the lowering of MRLs or low and missing MRLs in key export markets can disrupt pest management techniques, including IPM practices. The process of creating an IPM program can be expensive and time-consuming, representing decades of research and millions of dollars to fund, develop, and test. A change to any one part of the system (including a lowered MRL resulting in the loss of use of a pesticide) can negatively impact the effectiveness of the entire system, especially when there are limited or no pesticide alternatives.

While agricultural producers aim to minimize impacts on the environment and on plant and human health, the cultural controls developed and used as part of IPM systems often must be coupled with some pesticide use in order to be successful. Recent actions by key U.S. export markets to lower pesticide use have put some of these IPM systems at risk.

The integrity of these multifaceted IPM systems can be eroded by changes in MRLs in export markets. The non-chemical controls and practices used in IPM systems are generally insufficient to manage pest and disease pressures alone and are typically coupled with pesticide use in order to be successful.[60] After an IPM system is developed for a crop, unexpected changes to the system (such as the loss of a pesticide or a reduction in its MRL) can have unanticipated repercussions that can threaten the ability of growers to manage pest and disease pressure. This, in turn, can result in lower quality or yield loss, or put the growers' ability to meet export market MRLs at risk.

IPM systems are particularly vulnerable to MRL changes when the changes are implemented with only brief transition periods without giving growers enough time to develop alternative IPM practices. Industry representatives note that removing existing pesticide tools without offering farmers enough time to adjust processes or find alternatives can have a substantial negative impact on both farmers and the environment.[61] For example, a working group assessing alternatives in response to the recent ban of chlorpyrifos in California noted in May 2020 that it was not yet able to determine whether the increased use of alternatives to chlorpyrifos may have similar or even greater negative impacts on human health and/or the environment than the active ingredient they replace.[62]

Finally, several factors outside of growers' control, such as weather, the availability of labor and equipment, and new and emerging pest pressures, can limit their ability to fully incorporate IPM programs. This creates an additional need for flexibility in the use of pesticides when needed. Growers indicated that if they were to lose one of the few tools available to them as a result of the removal of an MRL in a major export market, the results could be the loss of that market or an increased risk of violations. Or, as discussed further in chapter 2, they state that they would face losses in yields and quality, as well as the potential for increased food safety risks.[63] Several case studies in this report describe the cost and complexity of IPM systems as well as the disruptive effects of missing or low MRLs.

[60] The aim of IPM is "the judicious use of pesticides" when it is determined through monitoring that pesticide use is required, and the goal is to use a pesticide to remove only the targeted organism. EPA, "Integrated Pest Management (IPM) Principles," September 28, 2015; industry representative, interview by USITC staff, August 14, 2020; UC IPM, "What Is Integrated Pest Management (IPM)?" (accessed August 26, 2020).
[61] Industry representative, interview by USITC staff, June 25, 2020; industry representative, interview by USITC staff, May 14, 2020; industry representative, interview by USITC staff, July 22, 2020.
[62] CDFA and DPR, "Towards Safer and More Sustainable Alternatives to Chlorpyrifos," May 2020, 39.
[63] Industry representative, interview by USITC staff, June 25, 2020; industry representative, interview by USITC staff, August 14, 2020.

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Chapter 2
Costs and Effects of Missing or Low MRLs: U.S. Producer Case Studies

The case studies presented in this chapter describe the costs and effects associated with MRL compliance and noncompliance for U.S. producers in meeting importing markets' MRLs, particularly when MRLs are missing or low. This chapter addresses this issue from the perspective of U.S. producers of a diverse range of crops, spread across different regions of the United States, and shipped to a wide variety of export markets (see table 2.1).[64] These case studies include a number of highly perishable fresh fruits and vegetables as well as products such as hops and nuts, which have a longer shelf life, and illustrate how compliance and noncompliance with import market MRLs affect U.S. farmers producing a variety of specialty crops.[65]

Specialty crops are often disproportionately affected by MRL issues, including when MRLs are missing, low, or diverging, in part because they are generally minor crops. The limited production of specialty crops in some markets can reduce the domestic demand for MRLs. If expected sales of these crops are relatively small, prospective pesticide registrants may hesitate to undertake the often costly effort to register pesticides and establish MRLs for these crops. This can reduce the number of pesticides and MRLs available to specialty crop farmers both domestically and in import markets. The limited availability of pesticides and MRLs for specialty crops are explored in greater detail in volume 1, both in chapter 4 and in several foreign producer case studies in chapter 5, as well as in this chapter.

Highly perishable specialty crops are often disproportionately affected by MRL violations, given how quickly their quality can deteriorate while awaiting further testing or while exporters attempt to find alternate markets for rejected shipments. Specialty crops with longer shelf lives, on the other hand, face challenges related to the length of time spent in the channels of trade—the time it takes from harvest to reaching buyers.[66] The timing of changes to MRLs is particularly problematic for crops like nuts, dried products, or some processed products. For example, these farmers may need to either phase out the use of pesticides well in advance of future MRL changes or face potential violations.

The costs and effects associated with MRLs, especially when they are missing or low, vary widely, depending on a variety of factors, including whether producers choose to bear the costs of complying with the import market MRL or whether they chose not to comply and lose access to that market as a result. Some of the most important issues highlighted in the case studies that follow are presented in table 2.1, which also identifies main U.S. growing areas and key export markets for the specialty crops addressed in this chapter.

[64] Missing and low MRLs are defined in chapter 1 of volume 1 of this report.
[65] In the United States, specialty crops are defined as "fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops (including floriculture)." USDA, "What is a Specialty Crop?" 2015.
[66] Further discussion of channels of trade issues is included in chapter 4 of volume 1 of this report.

Table 2.1 Case study crops, crop type, growing area, key export markets, and MRL issues

Crop	Crop type	U.S. growing areas	Key export markets	MRL-related issues discussed
Apples and pears	Temperate fruit	Washington, Oregon, California, New York	Mexico, Canada, Taiwan, Vietnam	Loss of MRLs, MRL violations
Celery	Vegetable	California, Arizona	Canada, Japan, Taiwan, Hong Kong	MRL violations
Chickpeas and lentils	Vegetable	Washington, Idaho, Montana, North Dakota	Canada, EU, Mexico, Pakistan, India	Pest pressures, MRL compliance
Cranberries	Temperate fruit	Wisconsin, Massachusetts, New Jersey, Oregon, and Washington	EU, China, Mexico, Canada, Malaysia	Loss of MRLs and missing MRLs, pest pressures and MRL compliance, channels of trade issues
Sweet cherries	Temperate fruit	Washington, Oregon, California, Idaho, Michigan	Canada, South Korea, Taiwan, Hong Kong, Vietnam	Pest pressures, MRL compliance, MRL violations
Tart cherries	Temperate fruit	Michigan, Utah	Japan, South Korea, Canada, EU, China	Missing MRLs, pest pressures, MRL compliance
Sweet potatoes	Vegetable	North Carolina, California, Mississippi	EU, Canada, Mexico, Costa Rica, New Zealand	Low and missing MRLs, pest pressures, MRL compliance
Pistachios and almonds	Edible nuts	California	EU, India, Canada, Japan, United Arab Emirates	Pest pressure, IPM strategies, MRL compliance, channels of trade issues
Hops	Other	Washington, Oregon	EU, Canada, Mexico, Brazil, Australia	Pest pressure, IPM strategies, MRL compliance, channels of trade issues

Source: Compiled by USITC.

The case studies cover specialty crops to major export markets, for which industry stakeholders have described MRL-related challenges. In particular, when asked about MRL-related challenges in major export markets, growers frequently mentioned challenges with the EU market, noting recent non-approvals or potential non-approvals of active ingredients, as well as its importance due to its size. As a result, several of the case studies discuss concerns from growers about changes to the EU market, though other major markets for U.S. agricultural production, including South Korea, Taiwan, and Japan, are also discussed. (The regulatory structures of the largest of these markets are summarized briefly in chapter 1 of this volume, while further detail is presented in chapter 3 of the first volume of this report.)

The case studies provide examples of how growers, processers, and exporters respond to changes in MRLs, including the need to find alternative export markets, use alternate pesticides, or adjust farming practices. Exporting U.S. producers are increasingly faced with growing pest pressures while constrained by limited crop protection options due to the reduction or absence of MRLs in major export markets. In order to comply with foreign market MRLs, domestic growers may be forced to use more costly or more labor-intensive alternatives or use less effective pesticide alternatives that result in yield losses or lower-quality products. Growers may also choose to forgo the export market if the costs of complying are too high. These choices can increase costs and reduce the overall profitability and farm income of U.S. producers.

The case studies also highlight some of the strategies U.S. producers use and decisions they make when confronted with low, varying, or missing MRLs in key U.S. export markets. For example, some may attempt to grow all of their crops to the lowest global MRL or segregate crops by pesticide used. They may also conduct pretesting of treated agricultural products to help reduce the risk of MRL violations.

The heavy reliance of many U.S. industries on highly complex IPM programs, while designed to balance pesticide use with other pest management strategies as detailed in chapter 1, can make compliance with changes in MRLs more difficult and costly. The following case studies, particularly of nuts and hops, provide examples of the costs incurred and the time taken to develop these systems, the complexity of the systems, the costs to growers of implementing these systems, and the risk of disrupting these systems when farmers confront low or missing MRLs.

The U.S. case studies presented in this chapter also provide examples of MRL violations and the consequences of exceeding MRLs in export markets, including loss of revenue through destruction or redirection of an agricultural commodity shipment and through increased testing requirements. Table 2.2 highlights the major challenges and concerns faced by U.S. industry stakeholders and specific examples by industry.

Table 2.2 Challenges and concerns related to missing or low MRLs

Issue	Challenges and concerns	Impacts
MRL-related challenges in the agricultural supply chain	MRL changes in key markets can lead to increased costs and may limit growers' ability to deal with pest challenges.	• Finding alternate markets (apples, pears) • Finding alternative pesticide products or pesticide use patterns (cranberries, nuts, hops) • Negative effects on complex IPM strategies (nuts and hops)
MRL-related challenges in the agricultural supply chain	Varying MRL policies affecting growers and exporters can complicate regulatory compliance and threaten market access.	• Inability to secure an import tolerance (pistachios) • Default MRL policies (celery, cherries) • Transition periods for new MRLs (cranberries, nuts hops)
Cost of compliance with MRLs	Complying with low, missing, or changes in MRLs impacts growers by affecting the pesticides they can use and can significantly impact both pre- and post-harvest costs.	• Segregating crops or growing to meet the lowest MRL (apples, pears, hops) • Pre-export testing and MRL monitoring costs (celery, cherries, lentils)
Costs of an MRL violation	Violations impact producers along the supply chain and can extend to other agricultural sectors.	• Loss of agricultural commodity revenue and redirected shipments (apples, pears, potatoes) • Increased testing (sweet cherries, celery, potatoes)

Source: Compiled by USITC.

Apples and Pears

The United States is one of the world's largest producers of apples and pears, with combined annual U.S. production valued at more than $3 billion.[67] Although the United States is a major supplier to a variety of export markets, U.S. producers have cited the loss of MRLs in the EU as contributing to a substantial decline in U.S. exports there. The EU, which had previously been the third-largest U.S. export market for apples, has notably reduced its imports of both pears and apples from the United States in recent years (from $20.9 million in 2012 to $2.2 million in 2020), such that it is no longer a top destination for the fruit. Subsequently, apple and pear producers have shifted exports to less MRL-restrictive markets and have engaged in pre-export testing to limit the likelihood of MRL violations. Pre-export testing and monitoring MRLs in export markets has been reported to cost the industry up to $25 million annually.[68] Despite these measures, the U.S. apple and pear sectors have continued to experience multiple MRL violations in export markets, often due to missing MRLs. These violations have raised costs due to destroyed shipments and increased inspections in some key markets.

Industry Overview

Within the United States, apple and pear production is largely concentrated in the Pacific Northwest. Washington State produces more apples than any other state (in some years constituting more than 50 percent of total U.S. apple production), followed by New York, California, and Oregon.[69] Pears are grown in similar places; the majority of U.S. pears are produced in Washington, Oregon, and California, while most of the remainder are grown in Michigan, New York, and Pennsylvania.[70] In volume terms, U.S. apple production is typically five to six times larger than U.S. pear production.[71]

[67] Apples constitute the vast majority of the total value of both crops. In 2019, the value of U.S. apple production was approximately $2.7 billion, while total U.S. pear production came to about $347 million. In most years approximately half of U.S. pear production is exported; in 2019, for example, the U.S. pear sector exported approximately $163 million in production. By contrast, about one-third of U.S. apple production is exported in most years. USDA, NASS, "National Statistics for Apples," 2020; USDA, NASS, "National Statistics for Pears," 2019; Agricultural Marketing Resource Center, "Pears," July 2015.

[68] Industry representative, email message to USITC staff, September 25, 2020.

[69] One industry organization estimates that apples are grown commercially in at least 32 U.S. states. American Farm Bureau Foundation, "Celebrating the Apple All Year Round," October 13, 2017.

[70] Washington is the largest pear producer, and typically produces between 35 and 50 percent of the annual U.S. pear crop. Oregon and California are typically second and third in production. Geisler, "Commodities and Products: Pears," July 2015.

[71] USDA, NASS, "National Statistics for Apples," 2020; USDA, NASS, "National Statistics for Pears," 2019.

Trade

While they may vary from year to year, U.S. exports of apples and pears represent a significant share of production. While most U.S. production is destined for domestic consumption, export markets are an important sales channel for the U.S. industry.[72] In 2019, the U.S. Department of Agriculture (USDA) estimated that approximately 18 percent of U.S. apples were exported. In most years about half of U.S. pear production is exported, although this can vary from 20 to more than 50 percent.[73] The United States typically exports apples and pears to either Canada or Mexico (figure 2.1 and 2.2), and U.S. exports to both markets have been fairly stable.[74] Pear exports are concentrated more in the North American market than apples, with over 80 percent of U.S. pear exports destined for Mexico and Canada in 2019 (for apples, the share was nearly 50 percent that year).[75] Exports are important to U.S. apple and pear growers because of the need to sell all sizes and qualities of apples and pears produced in an orchard (sometimes referred to as “selling the whole tree”) and the fact that demand for certain sizes, qualities, and varieties can be higher in certain export markets than in the United States.[76]

The EU was the third-largest export market for U.S. apples until 2012. However, between 2012 and 2019, U.S. apple exports to the EU fell by nearly 90 percent; pear exports fell by nearly 100 percent (see figure 2.1). Industry representatives attribute this decline in part to the elimination of certain EU MRLs during this period.[77]

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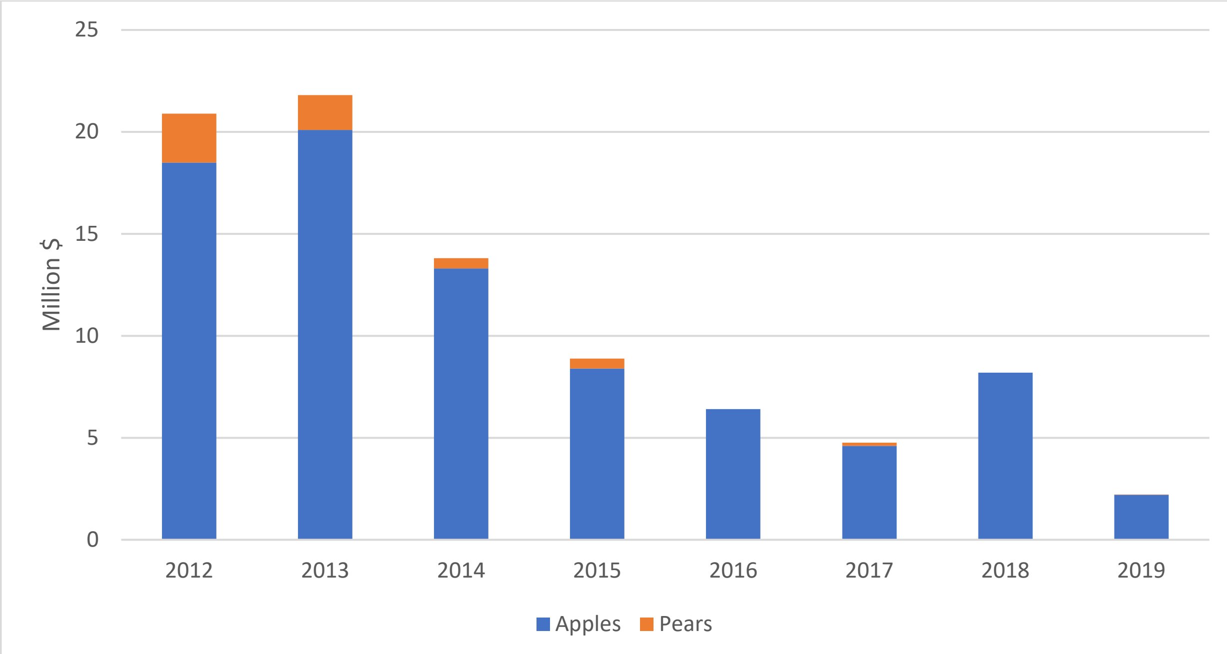
[72] Industry representatives estimate that U.S. apple production supplies about 90 percent of the domestic apple market. In 2018, the United States produced approximately $3.0 billion in apples, of which $1.0 billion was exported and $2.0 billion was consumed domestically. In that year, the United States imported approximately $200 million in apples, with Chile as the largest source of imports. Karst, “U.S. Apple Exports Outpace Imports Fivefold in 2018,” March 24, 2019; USDA, FAS, “Fresh Apples, Grapes, and Pears: World Markets,” June 2020.
[73] USDA, ERS, “Data by Commodity—Imports and Exports: Pears” (accessed October 5, 2020).
[74] Industry representatives in multiple crop sectors have not noted many major MRL challenges in the Canadian or Mexican markets. This may help partially explain the relative stability of U.S. exports of apples and pears to Mexico and Canada, in contrast to the significant decline in exports to the EU.
[75] NHC, written submission to USITC, December 13, 2019, 14.
[76] Industry representative, interview by USITC staff, June 23, 2020.
[77] Industry representative, interview by USITC staff, June 23, 2020.

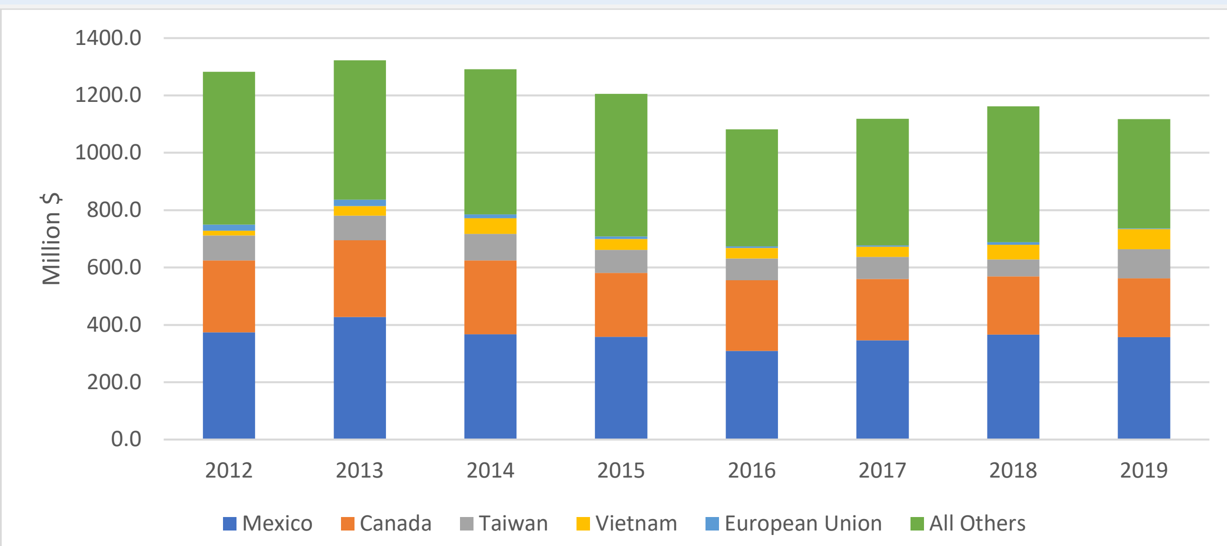
Figure 2.1 U.S. exports of apples and pears to the European Union, 2012–19 (million dollars)



Source: Source: USITC/USDOC DataWeb, HTS 0808.10 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Corresponds to appendix table H.3.

Beyond the North American market and the EU, several Asian markets have emerged as significant importers of U.S. apples and pears. Taiwan and India are top export destinations for both U.S. crops, while Vietnam, Indonesia, Hong Kong, and Thailand were among the top 10 U.S. apple export destinations in 2019.

Figure 2.2 U.S. exports of apples and pears to major markets, 2012–19 (million dollars)



Source: Source: USITC/USDOC DataWeb, HTS 0808.10 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Corresponds to appendix table H.4.

Pest Pressures and Pesticide Use

The U.S. apple and pear industries face ongoing pressure from several types of insect, bacterial, and fungal pests, which are often addressed with a combination of cultural controls (such as pruning trees during dormancy or clearing fields) and the application of pesticides. Insect pests include aphids, apple maggots and apple rust mites, codling moth, and leafhoppers.[78] Diseases affecting the apple and pear sectors include pear and apple scab, fire blight, sooty blotch, black and white rot, and black spot.[79] All of these pests can damage the trees, leaves, and fruits of apple and pear trees.[80] If left untreated, these pests can contribute both to substantial short-term yield loss and to lasting damage, including injuries to tree root systems which can permanently damage trees.[81]

In order to address these pest pressures, apple and pear growers use a variety of pesticides. These include carbaryl, which supports apple thinning (a process of reducing blossoms to prevent damage to tree branches and to prevent future insect infestation); chlorpyrifos and fenpropathrin, which combat aphids; boscalid, which addresses mold challenges; diphenylamine (DPA), which prevents scalding of fruit skins after harvest; and thiabendazole, which is often used to treat a variety of bacterial challenges (blight, rot, trichinosis, and blue and gray mold). In several cases, a particular pesticide is described by industry representatives as the best pesticide for addressing a particular pest challenge, as the most cost-effective solution, or as preferable because it requires smaller quantities than alternatives. In some instances, there is reportedly no equally effective alternative pesticide or cultural control method.[82] In other instances, industry representatives note that multiple pesticides may be used to address a single pest pressure (boscalid and pyraclostrobin, for example, are both used to address powdery mildew and scab), and that having a variety of pesticide options can limit the rise of pest resistance to any one pesticide.[83]

Costs and Effects of Missing and Low MRLs

Given the variety of pest pressures facing the U.S. apple and pear sectors, industry representatives have expressed concern about several MRLs for key insecticides (carbaryl, chlorpyrifos) and fungicides (DPA, mancozeb) in key export markets and Codex (see table 2.3 for MRLs used in the apple industry and table 2.4 for MRLs used in the pear industry).[84] In the EU, MRLs for several of these crop protection tools have recently changed, or changes to MRLs are pending. In 2012 and 2014, as part of its systematic review of existing approved active substances, the EU non-approved carbaryl and DPA, and MRLs were subsequently lowered for apples and pears. The EU also did not renew its approval of chlorpyrifos in

[78] University of Massachusetts, "IPM Guidelines for Apple" (accessed September 25, 2020).
[79] Douglas, "Disease Control for Home Pear Orchards" (accessed September 25, 2020).
[80] University of Massachusetts, "IPM Guidelines for Apple" (accessed September 25, 2020); Douglas, "Disease Control for Home Pear Orchards" (accessed September 25, 2020).
[81] Gauthier, "Fruit Diseases of Apple" (accessed September 25, 2020).
[82] Industry representative, interview by USITC staff, June 23, 2020.
[83] Industry representative, interview by USITC staff, June 23, 2020.
[84] The Codex Alimentarius Commission (CAC) is an international organization that sets MRLs for crops. Certain markets defer to or set their domestic MRLs to align with Codex, while others may consider Codex MRLs when setting domestic MRLs. Further information on market adoption of Codex MRLs can be found in chapter 1 of this report, as well as chapters 2 and 3 of the first volume of this report.

2019, and this MRL for both apples and pears defaulted to the limit of determination of 0.01 parts per million (ppm) in early 2020.[85] Further, EU approval for mancozeb expires in January 2021, and the active substance was notified to the WTO for non-renewal in April 2020, and apple and pear industry representatives expressed concern that approval of the use of mancozeb may not be renewed.[86] If the EU does not reapprove the registration of mancozeb, the industry expressed concern that the EU MRLs for mancozeb in apples and pears will subsequently be reduced or eliminated to the LOD, lowering it below the existing U.S. tolerance for mancozeb on apples and pears. Additionally, they stated that despite the existence of import tolerances as a policy tool for the EU and other major export markets, any import tolerances will likely be set to a default. While the majority of industry representatives' concerns were with the EU, the industry has also faced MRL violations in other key market due to missing or low MRLs.

As a result of these changing MRLs, the domestic apple and pear sectors have responded in multiple ways in recent years. They have shifted exports to markets with less restrictive apple and pear MRLs, such as Vietnam and Taiwan, and have engaged in pre-export testing to limit the likelihood of MRL violations. However, despite these measures, the apple and pear sectors have still experienced multiple MRL violations in export markets. The violations have increased exporters' costs from rejected shipments and subsequent increased inspections.

Table 2.3 MRLs for key active ingredients used in the apple industry (parts per million)
Some values in cells are marked with footnote letter a, meaning that an MRL is "missing"—it has not been set by the relevant regulatory body. Others are marked with footnote letter b, meaning that an MRL is set to that market's default value (usually a very low MRL).
n.a. = not applicable

Active ingredient	Pesticide type	Codex	Canada	United States	Japan	EU	Notes
Boscalid	Fungicide	2.0	3.0	3.0	2.0	2.0	n.a.
Carbaryl	Insecticide	n.a.[a]	5.0	12.0	1.0	0.01[b]	EU MRLs amended to default in 2014, previously set at 0.05 ppm for apples.
Chlorpyrifos	Insecticide	1.0	0.01	0.01	1.0	0.01[b]	Chlorpyrifos was non-approved in the EU in 2019. Previously, the apple MRL was set at 0.5 ppm.
Diphenylamine (DPA)	Fungicide	10.0	5.0	10.0	10.0	0.05	Diphenylamine was non-approved in the EU in 2012. Previously, the apple MRL was set at 5 ppm. The current EU MRL is an emergency authorization, which was renewed in 2016.
Fenpropathrin	Insecticide	n.a.[a]	5.0	5.0	5.0	0.01[b]	Prior to default in 2009, fenpropathrin MRLs were set by EU member states, some of which were higher than 0.01 ppm.
Mancozeb	Fungicide	5.0	7.0	0.6	5.0	5.0	n.a.
Thiabendazole	Fungicide	3.0	10.0	5.0	3.0	4.0	n.a.

Source: Compiled by USITC, using Bryant Christie Global Pesticide MRLs database for active ingredients shown (accessed September 25, 2020).

[85] Limit of determination is explained in chapter 1 of this report.
[86] The European Chemicals Agency (ECHA) determined mancozeb is a toxic substance for reproduction due to brain malformations caused by a mancozeb metabolite, ethylene thiourea. EFSA determined it was also an endocrine disruptor. The EPA is currently reviewing the U.S. approval of mancozeb. Chemycal, "EU Draft Regulation Implementing Regulation concerning the non-renewal of the approval of the active substance mancozeb," April 18, 2020.

Table 2.4 MRLs for key active ingredients used in the pear industry (parts per million)
Some values in cells are marked with footnote letter a, meaning that an MRL is "missing"—it has not been set by the relevant regulatory body. Others are marked with footnote letter b, meaning that an MRL is set to that market's default value (usually a very low MRL).
n.a. = not applicable

Active ingredient	Pesticide type	Codex	Canada	United States	Japan	EU	Notes
Boscalid	Fungicide	n.a.[a]	3.0	3.0	3.0	1.5	n.a.
Carbaryl	Insecticide	n.a.[a]	5.0	12.0	5.0	0.01[b]	EU MRL amended to default in 2014. Previously, the pear MRL was set at 0.05 ppm.
Chlorpyrifos	Insecticide	1.0	0.1[2]	0.05	0.5	0.01[b]	Chlorpyrifos was non-approved in the EU in 2019. Previously, the pear MRL was set at 0.5 ppm.
Diphenylamine (DPA)	Fungicide	5.0	0.1[2]	5.0	5.0	0.05	Diphenylamine was non-approved the EU in 2012. Previously the pear MRL was set at 10 ppm.
Fenpropathrin	Insecticide	n.a.[a]	5.0	5.0	5.0	0.01[b]	Before being set to the default level in 2009, fenpropathrin MRLs were set by EU member states, some of which were higher than 0.01 ppm.
Mancozeb	Fungicide	5.0	7.0	0.6	5.0	5.0	n.a.
Thiabendazole	Fungicide	3.0	10.0	5.0	3.0	4.0	n.a.

Source: Compiled by USITC, using Bryant Christie Global Pesticide MRLs database for active ingredients shown (accessed September 25, 2020).

Changing MRL levels have substantially impacted U.S. exports for apples and pears to the EU market. DPA is used after apples and pears are picked to prevent fruit scald (a browning of skin that can contribute to fungus infestations) in storage before they are shipped.[87] In 2009, the EU adopted regulations which harmonized EU policy for registering active ingredients and setting MRLs.[88] Following the introduction of this unified framework, the EU authorization for the use of DPA was withdrawn in 2012, and its MRLs for both apples and pears were reduced from 0.1 ppm to 0.05 ppm (a level that is significantly lower than current U.S. and Codex MRLs, tables 2.3 and 2.4). Since meeting these reduced MRLs would have increased the risk of fruit scalding during cold storage and because segregating crops (described below) is reportedly not feasible for apple and pear processors, domestic apple and pear growers chose not to reduce the amount of DPA used in production.[89] Subsequently, during the period 2012 to 2019, U.S. apple exports to the EU declined from $18.5 million in 2012 to $2.2 million in 2019, or 88 percent. Pear exports from the United States to the EU fell by more than 99 percent between 2012 to 2019, from $2.4 million in 2012 to less than $10,000 in 2019.[90]

[87] EWG, "Most U.S. Apples Coated with Chemical Banned in Europe," April 24, 2014.
[88] The adoption of EU Regulation (EC) No 396/2005 and Regulation (EC) No 1107/2009, which harmonized the active substance registration and MRL processes in the EU, is discussed in more detail in chapter 3, volume 1 of this report.
[89] Northwest Horticultural Council, written submission to USITC, December 13, 2019, 5–6; industry representative, interview with USITC staff, June 23, 2020.
[90] USITC/USDOC DataWeb, HTS 0808.30 (accessed July 27, 2020); USITC/USDOC DataWeb, HTS 0808.10 (accessed July 27, 2020).

Another concern expressed by industry representatives is that segregating orchards by export market is often not feasible. Sometimes, if a portion of a crop from a given source can meet the MRLs in certain target markets, then that portion is segregated for export to those markets and the rest of the crop will be directed to other markets with higher MRLs. However, since segregating crops requires separate processing facilities and additional supply chain costs, this is not always feasible. Instead, apple and pear growers frequently attempt to grow their products to the lowest major export market MRL—though, as noted with DPA and fruit scald, this is impossible in some cases.[91] In instances where a particular pest pressure emerges that requires farmers to apply a pesticide at levels that would exceed the lowest market MRL for that pesticide, or where growing a crop to comply with a low market MRL is not possible or commercially feasible, production must often be diverted away from the export market with the lowest MRL in favor of other export markets (or, more frequently, the U.S. market).[92] This often results in lower reported returns as well as increased processing costs for exporters.

In addition to attempting to grow to the lowest export market MRL where possible, apple and pear producers will often also engage in pre-export residue testing to lower the likelihood of an MRL violation. However, this too can be costly. One industry group estimated that the cost to conduct individual residue tests is approximately $6,000–$8,000, and the Washington tree fruit industry estimates that it has spent approximately $200,000 in residue tests to meet foreign market MRL standards since 2011.[93] One industry representative estimated that the apple and pear industries have incurred direct personnel costs of more than $15 million annually to address MRL issues, and have spent more than $10 million per year in direct pre-export testing to ensure MRL compliance before fruit is shipped.[94]

Despite attempting to grow to the lowest export market MRL and conducting pre-export testing, the apple and pear sectors have also experienced MRL violations in multiple markets in the past 15 years. Combined, the apple and pear sectors experienced at least 17 MRL compliance violations or shipments delays between 2008 and 2019 (less than 1 percent of total shipments). However, in many cases these violations were due to a default MRL being applied as a result of a missing MRLs in the export markets, rather than detected violations of established MRLs.[95] In the apple sector, 2 MRL violations were detected in Taiwan in 2009 (because the corresponding MRL was missing), 6 in India in 2014 and 2018 (half of which were due to missing MRLs), 2 in Costa Rica in 2014 and 2018, and 3 in Israel in 2006, 2017, and 2018 (all of which were due to missing MRLs).[96] After these shipments were rejected at port, they were usually destroyed.[97]

The pear sector appears to have experienced fewer noted violations for exceeding foreign market MRLs or missing MRLs, with 1 in Germany in 2011, 1 in India in 2015, and 2 in Israel in 2017.[98] However, the pear shipment rejection in Germany had lasting impacts; according to industry representatives, this

[91] Industry representative, interview by USITC staff, June 23, 2020.
[92] Industry representative, interview by USITC staff, June 23, 2020.
[93] Industry representative, email message to USITC staff, September 25, 2020; NHC, written submission to USITC, December 13, 2019, 13.
[94] Industry representative, email message to USITC staff, September 25, 2020.
[95] NHC, written submission to USITC, December 13, 2019, 32–33.
[96] NHC, written submission to USITC, December 13, 2019, 32–33.
[97] Industry representative, email message to USITC staff, September 25, 2020.
[98] NHC, written submission to USITC, December 13, 2019, 32–33.

rejection contributed to the German cancellation of future pear shipments to Germany.[99] The cost of a rejected shipment for the pear and apples sectors can be as high as $40,000 per rejection, including $4,000 in reshipment costs and $6,000 in the reduction in fruit quality for reshipped products.[100]

An MRL violation can have a particularly significant impact on certain segments of the apple and pear sectors, given export markets' preferences for particular varieties.[101] The MRL violation for pears in Germany, for example, was particularly impactful for red Anjou pears, a variety more likely to be shipped to the German market than to other U.S. export markets.[102] Given consumer preferences in export markets, redirecting shipments from one market to another in the event of a shipment rejection can also lead to lower prices for the product due to lower consumer demand.[103]

Celery

The United States is one of the world's largest producers of celery, with a crop value of $475 million in 2019. Although the majority of U.S. production is consumed domestically, export markets are important to this industry. Japan is the second-largest export market (after Canada) for U.S. growers, worth $4.3 million in 2019. The U.S. industry experienced MRL violations on celery in Japan as a result of a reduction in Japan's temporary MRL on acephate on celery. These MRL violations not only resulted in enhanced inspection and port delays for the grower-shippers that triggered the violations, but the entire U.S. celery industry was also subsequently subject to enhanced inspection regimes. U.S. industry representatives are concerned that enhanced inspections could contribute to revenue losses from reduced demand and lower prices in Japan.

Industry Overview

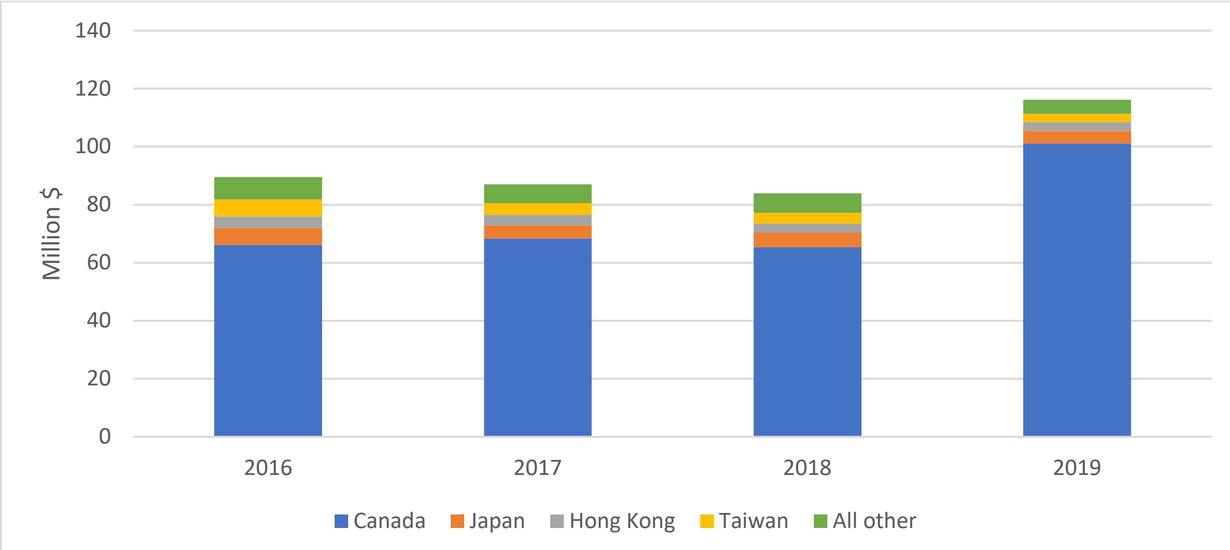
Celery is a cool-season vegetable and, depending on the variety, either the root or stalk can be consumed. In the United States, production and consumption is primarily of the stalk, which is mostly consumed fresh, though it can also be processed into dry or powered products or used as an ingredient in prepared foods.[104] The United States produced 880,000 tons of celery in 2019.[105] California produces the vast majority of the U.S. crop, but Arizona is a major celery producer in the fall and winter off-season.[106]

[99] NHC, written submission to USITC, December 13, 2019, 32–33.
[100] NHC, written submission to USITC, December 13, 2019, 5–6.
[101] Industry representative, interview by USITC staff, June 23, 2020.
[102] NHC, written submission to USITC, December 13, 2019, 32–33.
[103] Industry representative, interview by USITC staff, June 23, 2020.
[104] Agricultural Marketing Resource Center, "Celery," October 2018.
[105] USDA, NASS, Quick Stats database (accessed July 16, 2020).
[106] USDA, NASS, Quick Stats database (accessed July 16, 2020); industry representative, telephone interview by USITC staff, June 30, 2020; Dimson, "Celery Production in Arizona," February 2001.

Trade

Most U.S. celery production is consumed domestically; in 2019, 12 percent of U.S. celery production was exported.[107] As seen in figure 2.3, Canada, whose MRLs on celery reportedly do not pose significant issues for the U.S. industry, is the largest foreign market for U.S. celery, accounting for 87 percent of total exports in 2019.[108] Other leading markets are Japan, Hong Kong, and Taiwan.[109]

Figure 2.3 U.S. exports of celery to major markets, 2016–19 (million dollars)



Source: USITC/USDOC DataWeb, HS 0709.40 (accessed July 27, 2020).
Note: Corresponds to appendix table H.5.

Pest Pressures and Pesticide Use

Aphids—small sap-sucking insects—are a significant pest in celery production.[110] Aphids can cause substantial damage to celery by stunting plant growth, spreading viral diseases, and contaminating the celery with their droppings. The resulting damage can reduce the market value of the crop. [111]

There are few effective biological controls available to control aphids in celery, so growers largely rely on pesticides. [112] Arizona growers use the insecticide acephate to control aphids; growers in California, who represent the majority of U.S. celery production, tend to use other products.[113] Besides acephate, there are a number of options for pesticide applications to control aphids, including spirotetramat and

[107] USDA, NASS, Quick Stats database (accessed July 16, 2020); USITC/USDOC DataWeb, Schedule B 0709.40 (accessed July 27, 2020).
[108] Industry representative, email message to USITC staff, September 22, 2020.
[109] USITC/USDOC DataWeb, HS 0709.40 (accessed July 27, 2020).
[110] Dimson, “Celery Production in Arizona,” February 2001.
[111] Godfrey and Trumble, “UC IPM: UC Management Guidelines for Other Aphids,” June 2008.
[112] Dimson, “Celery Production in Arizona,” February 2001.
[113] Celery farmers in California have been applying less acephate since the state restricted the use of this active ingredient. Industry representative, telephone interview by USITC staff, June 30, 2020.

sulfoxaflor, some of which may be newer and therefore likely more expensive.[114] The neonicotinoid imidacloprid can also be applied before planting as a preventative measure, but preventative applications of pesticides are reportedly expensive.[115] Also, repeated applications of a single neonicotinoid insecticide can increase pest resistance to all neonicotinoids, reducing their effectiveness over time and ultimately increasing pest management costs.[116]

To meet an MRL, farmers typically apply pesticides based on a specified pre-harvest interval (PHI), the minimum time between the last application of the pesticide and the harvesting of the crop. PHIs are used to set a withholding period during which the corresponding pesticide is not used in order to comply with an MRL. In the United States, there is a 21-day PHI between the last application of acephate on celery and the date when the crop can be harvested in compliance with the MRL. Growers may not be able to effectively use pesticides like acephate when MRLs are lower in destination markets. This is because complying with a lower MRL requires extending the PHI, which leaves the crop exposed to potential pest damage for a longer period.[117]

Costs and Effects of Missing and Low MRLs

Although its purchases are small relative to U.S. and Canadian sales, Japan is the second-largest export market for U.S. celery producers, as mentioned earlier. U.S. celery producers noted that the negative effect of Japan's reduction of the MRL for acephate in 2018 had cascading effects throughout the U.S. sector, and coincided with a 12 percent decline in exports to Japan between 2018–19.[118] Table 2.5 presents Japan's MRL for acephate.

In 2006, Japan had established a temporary MRL of 10 ppm that was on par with that of the U.S. tolerance for celery.[119] However, at the end of February 2018, Japan noted its intent to reduce the temporary MRL to the default level of 0.01 ppm in October 2018.[120] While in some cases a grower might be able to comply with a default MRL, compliance is particularly challenging when that MRL is set very low relative to the U.S. MRL.[121] In this case, Japan's default MRL is 1,000 times lower than both the U.S. MRL and Japan's temporary MRL on acephate.

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[114] Fournier et al., "Acephate Use in Several Arizona and New Mexico Crops," August 22, 2018.
[115] Dimson, "Celery Production in Arizona," February 2001.
[116] Godfrey and Trumble, "UC IPM: UC Management Guidelines for Other Aphids," June 2008.
[117] Industry representative, telephone interview by USITC staff, June 30, 2020.
[118] USDA, NASS, Quick Stats database (accessed July 16, 2020).
[119] USDA, FAS, *Japan: Japan Proposes Revision of MRLs*, March 1, 2018.
[120] USDA, FAS, *Japan: Japan Proposes Revision of MRLs for 8 Agricultural Chemicals*, March 1, 2018; Lexagri International, Homologa database (accessed multiple dates).
[121] See chapter 4 of volume 1 of this report for further discussion of the impacts of low default MRLs.

Table 2.5 MRLs for key active ingredient used in the celery industry (parts per million)
Some values in cells are marked with footnote letter a, meaning that an MRL is “missing”—it has not been set by the relevant regulatory body. Others are marked with footnote letter b, meaning that an MRL is set to that market’s default value (usually a very low MRL). If a cell value is marked with footnote letter c, that means the MRL is “temporary,” i.e., pending further regulatory review.

Active Ingredient	Pesticide type	United States	Codex	Canada	Japan	South Korea	Hong Kong	Taiwan	Notes
Acephate	Insecticide	10.0	n.a.[a]	5.0	0.01[b]	10.0[c]	1.0	4.0	Japan had a temporary MRL of 10.0 ppm until October 2018.

Source: Compiled by USITC, using Lexagri International, Homologa database for active ingredients shown (accessed multiple dates).

Following the change in October 2018, there were reports of acephate MRL violations involving U.S. shipments of celery to Japan in summer 2019.[122] The MRL violations resulted in enhanced enforcement and testing on 30 percent of all celery shipments from the United States, not just on shipments from the offending firm.[123] Additional violations may result in the Japanese Ministry of Health, Labour and Welfare issuing an inspection order requiring all U.S. celery shipments to Japan be held for testing for one year, a process referred to as “100 percent hold and test.”[124] Such an inspection order can result in port delays and an increase in storage and handling costs.[125] Because celery has a shelf life of little more than three weeks (including time for post-harvest packing, shipping, and retailing) this hold time at the port can diminish both the product’s quality and its resale value. Effectively, it means that the perishable product cannot be reshipped to a different market while it is being held by officials in Japan, nor be reshipped if testing fails.[126] Industry representatives noted that even if the shipment of celery successfully navigates this enhanced testing process, the market value may be reduced due to the loss in freshness and quality stemming from the perishability of celery.

In addition, industry representatives reported that while they wanted to amend the MRL quickly, the industry was unable to do so in part because of the lack of data and other supporting information required by regulatory authorities to establish MRLs. Acephate, which has been registered for use on food crops in the United States since 1973, is an older insecticide that is now sold in generic form.[127] Data collection challenges—particularly those facing minor crop growers who rely on older, generic chemicals—are described in detail in volume 1, chapter 4.

The low default MRL and the added costs borne by all exporters to Japan stemming from MRL violations contributed to U.S. celery farmers’ difficulty in growing their crop and exporting it to Japan. The industry’s main concern exporting to Japan surrounds the industry-wide consequences of the

[122] WGA, “U.S. Celery Export Violations Found in Japan,” August 6, 2019.
[123] Industry representative, telephone interview by USITC staff, June 30, 2020; WGA, “U.S. Celery Export Violations Found in Japan,” August 6, 2019.
[124] USDA, FAS, *Japan: Most MRL Import Violations Due to Lack of Harmonization*, May 12, 2020.
[125] USDA, FAS, *Japan: Most MRL Import Violations Due to Lack of Harmonization*, May 12, 2020.
[126] Industry representative, telephone interview by USITC staff, June 30, 2020.
[127] National Biomonitoring Program, “Biomonitoring Summary: Acephate,” April 7, 2017; Intermountain Tree Fruit Production Guide, “Generic Options for Common Insecticides,” Utah State University.

violations. The entire U.S. celery industry suffered because of the violations of individual shippers.[128] According to industry representatives, low default MRLs and the high costs of violation that all exporters face discourage participation in export markets.[129]

Pulses

The United States is the fifth-largest producer of chickpeas and the third-largest for lentils globally, producing nearly 660,000 tons annually of chickpeas and lentils combined, and exports are extremely important to this industry. Farmers of pulses (including lentil and chickpea farmers) in the United States rely on the active ingredient glyphosate both for weed control and as a desiccant to dry the crop before harvest. However, several export markets around the world are reviewing their pesticide and MRL policies regarding glyphosate. Industry representatives report that without the necessary MRLs for this key herbicide, particularly in the EU, the industry has few effective alternatives for these important steps in the growing process. The alternatives that do exist are reportedly less effective, contributing to income loss for growers through lower crop yields and quality. These commodities are frequently bulked and blended before export, and U.S. growers have noted that this practice has sharpened their concerns about being able to comply with low and missing MRLs in major export markets. Other industry representatives noted that these impacts could intensify if other export markets choose to align their own MRLs with those of the EU. [130]

Industry Overview

Lentils and chickpeas (garbanzo beans) are two important pulse crops[131] that grow in cool dryland agricultural areas.[132] The United States is a major producer of lentils and chickpeas, with lentil production valued at $79 million and chickpea production valued at $117 million in 2019.[133] Nearly 90 percent of the U.S. chickpea crop is grown in Washington, Idaho, and Montana, while North Dakota and Montana produce 80 percent of the nation's lentil crop.[134] As demand for pulse crops, particularly lentils and chickpeas, has grown domestically and around the world, lentils and chickpeas have become increasingly incorporated into crop rotations with grains such as wheat and barley. Pulses are planted after the winter grain crop is harvested in the spring instead of leaving the field fallow for the summer growing season. As the pulse crop grows over the summer, it retains soil moisture and naturally adds nitrogen to the soil. The winter grain crop is then planted after the lentils or chickpeas are harvested.[135]

[128] Industry representative, telephone interview by USITC staff, June 30, 2020.
[129] Industry representative, telephone interview by USITC staff, June 30, 2020.
[130] Industry representative, telephone interview by USITC staff, October 31, 2019
[131] Pulses are a group of 12 edible dry leguminous vegetables.
[132] Bond, "Pulses Production Expanding as Consumers Cultivate a Taste," February 6, 2017.
[133] The United States ranks third in the world for lentil production behind Canada and India, and ranks fifth for chickpea production behind India, Australia, Turkey, and Russia. USDA, NASS, Quick Stats database (accessed August 3, 2020); FAO, FAOSTAT database (accessed August 3, 2020).
[134] USDA, NASS, Quick Stats database (accessed August 3, 2020).
[135] Montana Department of Agriculture, "Pulse Crop Programs" (accessed August 4, 2020).

Demand for pulses, especially lentils and chickpeas, is growing globally, underpinned by trends towards consuming healthier foods and population growth.[136] Lentils and chickpeas are high in protein and fiber, making them an important staple food for a variety of markets around the world. Unprocessed pulses are a low-value product, but can be further processed and marketed in a variety of ways—from inexpensive bags of dry lentils to high-value products such as hummus and lentil pastas.[137] Retail sales in the United States of pulse products are estimated to have increased by $700–$800 million from just $10 million in the late 1990s.[138] Global demand for lentils is expected to increase by 2 million tons (34 percent) between 2016 and 2022.[139]

Trade

Export markets are important for the U.S. pulse industry. According to industry representatives, 75 percent of the U.S. lentil crop is exported, and depending on domestic demand for chickpeas, 50–60 percent of all U.S. grown chickpeas are exported.[140] In 2019, nearly 60 percent of U.S. pulse exports went to Canada, the EU, India, and Mexico (see figure 2.4). India is traditionally a major global market for peas and lentils, accounting for a quarter of global demand, receiving nearly one-quarter of U.S. exports of peas and lentils by volume in 2016.[141] However, in 2018, India imposed tariffs of up to 50 percent on pulses to protect domestic farmers, and the share of U.S. pulse exports to India had fallen to 6 percent by 2019.[142]

While both the EU and India are important markets for the U.S. pulse industry, different types of products are sent to the two markets for different returns. The EU accounted for about 21 percent of U.S. exports of pulses in 2019.[143] According to an industry representative, U.S. exports to the EU typically consist of heavily processed, higher-priced products like dry soup mixes.[144] On the other hand, products shipped to India tend to be at high volumes and low value, with minimal if any processing.[145] If there were a market disruption, such as from MRL regulations, that prevented the U.S. industry from selling premium product to the high-value EU market, the low-value Indian market would not likely make up for the lost revenue.[146]

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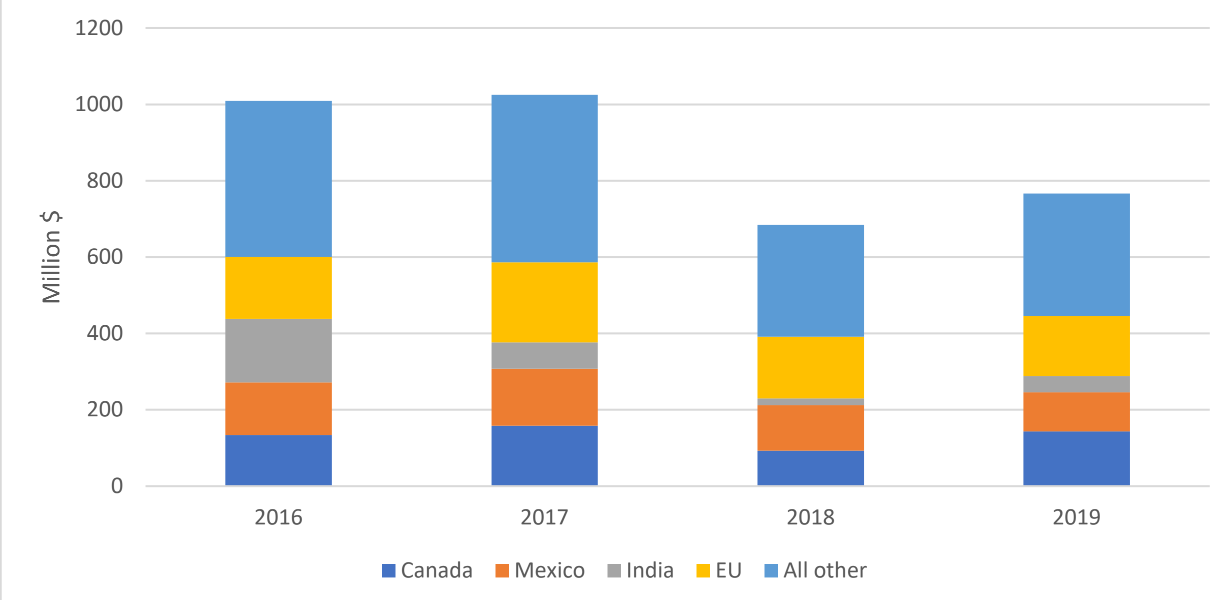
[136] Pratt, "Huge Market Potential for Pulses," May 7, 2020; Rawal and Navarro, "The Global Economy of Pulses," 2019, 190.
[137] Industry representative, telephone interview by USITC staff, June 29, 2020; Bond, "Pulses Production Expanding as Consumers Cultivate a Taste," February 6, 2017.
[138] Bond, "Pulses Production Expanding as Consumers Cultivate a Taste," February 6, 2017.
[139] Western Producer, "Pulses: Global Pulse Protein Demand Seen Rising," June 8, 2017.
[140] Industry representative, telephone interview by USITC staff, June 29, 2020.
[141] Industry representative, telephone interview by USITC staff, June 29, 2020.
[142] USDA, FAS, *India: Import Tariff Rate Increases for Lentils and Chickpeas*, December 22, 2017; USDA, FAS, *India: Pulses Market and Policy Changes*, September 28, 2018; Sokol, "India Tariffs Squeeze Out U.S. Pulse Imports," June 24, 2018; IHS Markit, Global Trade Atlas database, HS 0713, (accessed July 15, 2020).
[143] USITC/USDOC DataWeb, HS 0713 (accessed July 27, 2020).
[144] According to an industry representative, the EU buys 80–90 percent of its lentils from the United States and Canada. Industry representative, telephone interview by USITC staff, June 29, 2020.
[145] Industry representative, telephone interview by USITC staff, June 29, 2020.
[146] Industry representative, telephone interview by USITC staff, June 29, 2020.

Figure 2.4 U.S. exports of pulses to major markets, 2016–19 (million dollars)



Source: USITC/USDOC DataWeb, HS 0713 (accessed July 27, 2020).
Note: Corresponds to appendix table H.6.

Pest Pressures and Pesticide Use

Weeds are a major agronomic concern for low-growing pulse crops such as chickpeas and lentils.[147] Before planting, farmers spray a pre-emergence herbicide and then use a seed drill to plant through the dead weed debris. This pre-planting herbicide application prevents weeds from growing until the pea or lentil plants are strong enough to outcompete the weeds. As harvest time approaches, new weeds are sprayed with herbicide to avoid crop damage resulting from the stains that weeds leave on the dry seeds.[148]

During this weed removal stage, glyphosate serves as a key herbicide for U.S. growers. Glyphosate, discussed in chapter 5 of volume 1, is an important herbicide for chickpeas and lentils as well as other row crops such as corn, wheat, and soybeans. It is used about two weeks before harvest to control weeds.[149] These weeds can both damage the crop and prevent the crop from drying before harvest. Glyphosate is also used as a drying agent (or desiccant) to uniformly dry the crops in the field before harvest. Peas and lentils are harvested dried, but they do not naturally dry equally or at the same rate in the field. This can complicate the harvest, especially since the crops take nearly the complete growing season to mature to the point where they have dried enough to be harvested. However, waiting too long to harvest can expose the crop to adverse weather that damages the crop. Thus, the crop is subject to a narrow harvest window, and farmers closely watch the weather at harvest time. The use of glyphosate as a desiccant helps farmers time the harvest, while also controlling weeds; both of these

[147] Industry representative, telephone interview by USITC staff, June 29, 2020.
[148] Industry representative, telephone interview by USITC staff, June 29, 2020.
[149] Industry representative, telephone interview by USITC staff, June 29, 2020; USITC, *Global Economic Impact of Missing and Low Pesticide MRLs, Vol. 1,* June 2020, 268.

measures increase yields. [150] According to industry representatives, 80–90 percent of all lentils and 90–95 percent of chickpeas are desiccated using agricultural chemicals in a given year.[151]

Costs and Effects of Missing and Low MRLs

As noted above, glyphosate is an important product for the domestic pea and lentil industry, not only because it provides effective weed control but also because it helps desiccate the crop before harvest. Both of these uses help improve the quality of the crop and U.S. farmers' yields. Industry representatives are concerned about the status of glyphosate and glyphosate MRLs in multiple markets around the world, including in Europe,[152] Mexico, and in some Asian markets, particularly because the industry reportedly has few effective alternative pesticides or farming practices to use in lieu of glyphosate without incurring higher costs or harming production.

Industry representatives report that without glyphosate, the industry has few effective alternatives for these important steps in the growing process. Existing alternatives, including both alternative herbicides and alternative farming practices, are less effective than glyphosate and can contribute to income loss for growers through lower crop yields and quality.[153] This can increase the pulse grower's labor and input costs, since a less effective alternative may require more applications or be more labor-intensive.[154] Using alternate farming practices can also increase production risk and result in the loss of crop insurance.[155]

While there are some other chemical options for preharvest weed control and desiccation besides glyphosate, they are not as effective, according to industry representatives.[156] One alternative to glyphosate is the herbicide Gramoxone, which contains the active substance paraquat. This herbicide reportedly costs more than glyphosate, is not as effective at killing the weeds or desiccating the crop, and is more difficult for growers to use.[157] While the U.S. Environmental Protection Agency (EPA) found little risk to human health from consuming food that was grown with paraquat if the herbicide is applied

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[150] Industry representative, telephone interview by USITC staff, June 29, 2020.
[151] Industry representative, telephone interview by USITC staff, June 29, 2020.
[152] As discussed in more detail in chapter 5 of volume 1, the EU registration for glyphosate is due for renewal in December 2022, and industry stakeholders worry that it will not be renewed again. This concern stems from recent court cases and concerns raised by officials from several EU member states in the last renewal in 2017. Ribeiro, "Glyphosate" (accessed December 18, 2019); Marks, "Glyphosate Is Here to Stay in EU," August 14, 2018; U.S. Grains Council, National Corn Growers Association, and MAIZALL, written submission to USITC, December 13, 2019, 23–24.
[153] Ecorys, *Study Supporting the REFIT Evaluation*, October 10, 2018, 163; USITC, hearing transcript, October 29, 2019, 46, 30–31 (testimony of Terry Humfeld, Cranberry Institute), and 159–60 (testimony of Dale Thorenson, USA Dry Pea & Lentil Council); CI, written submission to USITC, December 11, 2019, 6; NABC, written submission to USITC, December 9, 2019, 2.
[154] NABC, written submission to USITC, December 9, 2019, 2; USITC, hearing transcript, October 29, 2019, 17, 48 (testimony of Alinne Oliveira, USHIPPC); USITC, hearing transcript, October 29, 2019, 30 (testimony of Terry Humfeld, Cranberry Institute); USITC, hearing transcript, October 29, 2019, 159–60 (testimony of Dale Thorenson, USA Dry Pea & Lentil Council); CRC, written submission to USITC, December 13, 2019, 7.
[155] Industry representative, telephone interview by USITC staff, June 29, 2020.
[156] Industry representative, telephone interview by USITC staff, June 29, 2020.
[157] Paraquat requires more training and mixing procedures and has been linked with Parkinson's disease. Industry representative, telephone interview by USITC staff, June 29, 2020; Tanner et al., "Rotenone, Paraquat, and Parkinson's Disease" (June 2011).

according to the registered label instructions, using paraquat is more difficult in part because of the safety procedures required to protect workers during application.[158] Also, MRLs are lower for paraquat in a number of markets than for glyphosate, as seen in table 2.6.

Table 2.6 MRLs for key active ingredients used in the chickpeas and lentils industry (parts per million)
Some values in cells are marked with footnote letter a, meaning that an MRL is "missing"—it has not been set by the relevant regulatory body. Others are marked with footnote letter b, meaning that an MRL is set to that market's default value (usually a very low MRL).
n.a. = not applicable

	United States	Codex	EU	Canada	India	Notes
Glyphosate	8.0	5.0	10.0	4.0	5.0	Before 2012, the EU MRL for lentils was 0.1 ppm and the Codex MRL was missing.
Paraquat	0.3	0.5	0.02	0.1[a]	n.a.[b]	n.a.

Source: Compiled by USITC, using Lexagri International, Homologa database (accessed multiple dates).

Swathing, an alternative farming practice, can be used for a limited number of crops in lieu of herbicides. However, it is a risky, costly, and less effective substitute. "Swathing**"** (also called "windrowing" outside of North America)[159] is a widely used practice for hay and some small grain crops whereby the crop is cut and swept into windrows to dry before combining or bailing (for hay). Swathing can be used in place of using herbicides to help desiccate some crops. Industry representatives report that while swathing is a realistic farming practice for lentils, it is not practicable for other pulses, including chickpeas.[160]

Moreover, there are also several major negative consequences associated with swathing. After the crop is swathed and is drying in the field for five to seven days, it is highly susceptible to damage from wind and rain.[161] Moreover, the crop, once swathed, is no longer insurable; insurance providers are aware of the risk of crop damage due to swathing and are often unwilling to assume the burden of potential losses.[162] In addition, even if farmers are able to avoid the wind and rain damage to the crop, they face a lower yield because more lentil seeds fall out of the pods in the swathing process. Industry representatives reported that when additional labor and yield loss are taken into account, swathing can add $20 per acre in cost in a market where farm revenue can be as low as $20 per acre.[163]

According to industry representatives, of the three options described above, glyphosate is the most cost effective, and this is important in a low-value, low-margin industry.[164] As one industry representative put it, if there were a 10-point scale ranking these three options, "glyphosate is an 8–10, Gramoxone® is a 5 or 6, and swathing is a 3 or 4" because it is "not a good option."[165] As glyphosate comes under increasing scrutiny around the world, particularly in the EU, the dry pea and lentil industry is increasingly

[158] EPA, "Paraquat Dichloride," February 26, 2016. In addition, a preliminary ecological risk assessment by EPA found "that all registered uses of paraquat pose a potential for direct adverse effects to" a range of wildlife. Judkins and Wente, "Paraquat: Preliminary Ecological Risk Assessment," June 26, 2019, 1.
[159] Industry representative, telephone interview by USITC staff, June 29, 2020.
[160] Industry representative, telephone interview by USITC staff, June 29, 2020.
[161] Industry representative, telephone interview by USITC staff, June 29, 2020.
[162] Industry representative, telephone interview by USITC staff, June 29, 2020.
[163] Industry representative, telephone interview by USITC staff, June 29, 2020.
[164] Industry representative, telephone interview by USITC staff, June 29, 2020.
[165] Industry representative, telephone interview by USITC staff, June 29, 2020.

concerned because a ban would mean switching to chemicals that are not as safe, affordable, or easy to use. Without glyphosate, industry representatives report that farmers would need to receive an additional $10 dollars per acre in revenue. Otherwise, farmers may stop producing, as sales may no longer be sufficiently profitable.[166]

The standard industry practice of bulking dry peas and lentils also presents foreign market MRL compliance challenges. Dry peas and lentils from different farms are collected and stored together in bulk storage containers. For example, pulses from 12 different fields are typically commingled in a single six-million-pound storage tank.[167] Farmers use EPA-approved chemicals, but industry representatives report that it is difficult to be certain that using chemicals at the approved rates will keep them under the MRLs in export markets, especially if those MRLs differ from domestic MRLs. For instance, for glyphosate, the U.S. MRL is 8 ppm and Canada's is 4 ppm; although the two MRLs are close, meeting the U.S. MRL does not necessarily mean meeting Canada's. The industry does conduct residue testing, but because the product is commingled, two tests of the same lot can easily get two different results. If an industry test comes back with unacceptable residues, it is nearly impossible to identify the farm and separate the product from that farm. According to an industry representative, the industry is trying to address this by testing for glyphosate at the farm level at harvest.[168] Getting test results reportedly takes 3–5 days.[169]

Collaboration between producers in different countries can make it possible to address shared MRL issues. In 2011, the U.S. and Canadian industries realized that the EU lacked approval for the pre-harvest application of glyphosate.[170] The lack of EU approval for the pre-harvest application meant there was a significant discrepancy between the U.S. MRL of 8 ppm for lentils and glyphosate, and the EU MRL, which was 0.1 ppm at the time. In addition, no Codex MRL for glyphosate on lentils existed.[171] To address the possibility of disruption in the valuable EU market, the U.S. and Canadian industries, which had domestic approval for pre-harvest application, worked together on these issues. The industries were able to get the EU MRL adjusted and a Codex MRL established in 14 months. The industry benefited from this process moving quickly because it can reportedly take up to 10 years, and they began this process at a time when the EU and Codex were already reviewing glyphosate.[172]

Cranberries

U.S. cranberries are a specialty crop with a value of close to $500 million in 2019.[173] Since most global cranberry production occurs in the United States, missing MRLs or changes to MRLs for cranberries in foreign markets are largely borne by the U.S. cranberry sector. Several pests represent a substantial challenge to the U.S. cranberry industry, and the loss of MRLs in certain key markets, or missing MRLs, can limit the ability of cranberry growers to effectively respond to these pest pressures. For example,

[166] Industry representative, telephone interview by USITC staff, June 29, 2020.
[167] Industry representative, telephone interview by USITC staff, June 29, 2020.
[168] Industry representative, telephone interview by USITC staff, June 29, 2020.
[169] Industry representative, telephone interview by USITC staff, June 29, 2020.
[170] Industry representative, telephone interview by USITC staff, June 29, 2020.
[171] Lexagri International, Homologa database (accessed September 24, 2020); USITC/USDOC DataWeb, HS 0713 (accessed July 27, 2020).
[172] Industry representative, telephone interview by USITC staff, June 29, 2020.
[173] USDA, "Another Large U.S. Cranberry Crop Expected in 2019," 2019.

the recent nonrenewal of chlorothalonil and chlorpyrifos in the EU and subsequent lowering of MRLs to the low default level is a concern for cranberry growers. Additionally, because cranberries are frequently processed before export and maintain a long shelf life, even the potential loss of a key MRL may reportedly lead farmers to proactively limit that pesticide's use, potentially affecting quality. As a result, a change in an MRL can undermine the marketability of a processed cranberry product well after the cranberry has been grown and harvested. Finally, the common practice of blending cranberries from various growers for export often contributes to an industry-wide effort to grow to the lowest MRL for commonly used pesticides among key export markets. These issues can contribute to yield loss (when cranberry growers are unable to effectively control emerging pest pressures), higher operational costs, and lower expected revenue for U.S. growers.

Industry Overview

Cranberries are a uniquely North American crop, and the industry is characterized by a range of small to very large farms. In 2017, the United States produced a majority of the world's cranberries, with over 380,000 tons of cranberry production, followed by Canada at about 176,000 tons.[174] Within the United States, cranberries are grown in several diverse geographic areas. Wisconsin is the largest grower of cranberries in the United States, accounting for 60 percent of U.S. cranberry production in 2019.[175] Massachusetts is the second-largest producer (27.3 percent of 2019 production), followed by Oregon and New Jersey (7.0 and 6.7 percent, respectively).[176] Cranberry production in the United States has steadily increased over the last three years, even as prices have declined.[177]

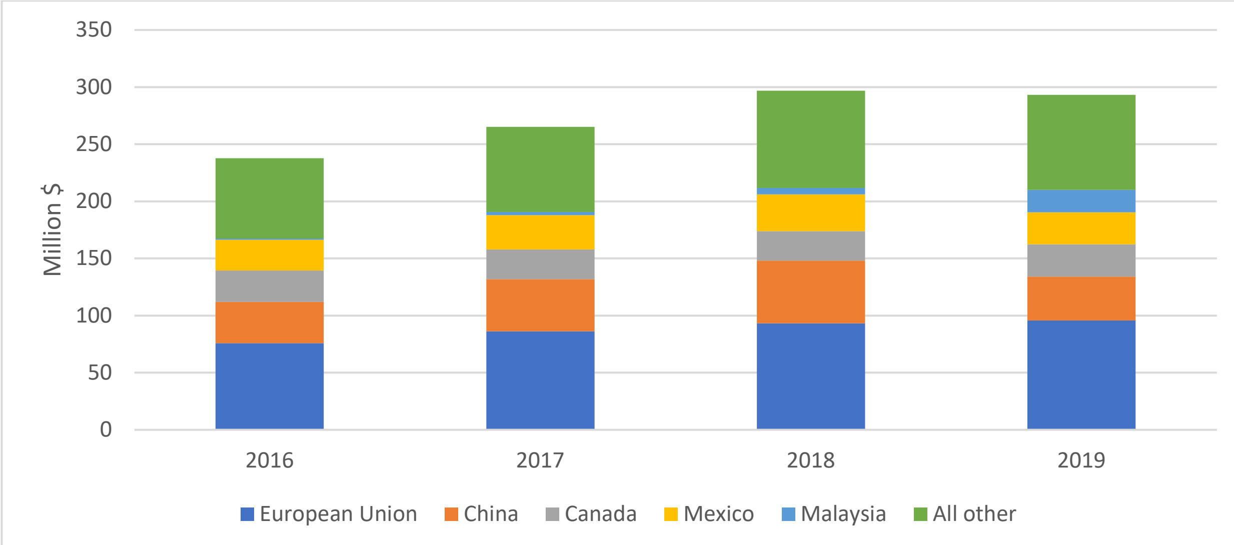
The vast majority of U.S. cranberry production is further processed into dried cranberries (usually around 80 percent of cranberry exports, as shown in figure 2.5) or cranberry juice (around 10 to 15 percent). Only a relatively small portion of cranberry production is sold fresh, and exports follow that trend. One industry representative noted that only about 2 to 3 percent of U.S. cranberry production was ultimately destined to be sold in its fresh form.[178]

Trade

The EU is the main export destination for U.S. dried cranberries, while U.S. export markets in Asia are growing. The EU represents the largest single export market for U.S. dried cranberries (figure 2.5), accounting for approximately 32 percent of total U.S. exports in 2019. Three of the 10 largest single-country export markets in 2019 were in the EU (the Netherlands, Poland, and the United Kingdom).[179]

[174] Chile, the next-largest producer, harvested 82,000 tons, but no other producer exceeded 10,000 tons that year. Burton, "Where Are Cranberries Grown?" September 4, 2018.
[175] Agricultural Marketing Resource Center, "Cranberries," January 2019.
[176] USDA, NASS, "Wisconsin Ag News—Cranberries," June 18, 2019.
[177] USDA, "Another Large U.S. Cranberry Crop Expected in 2019," September 2019; industry representative, interview by USITC staff, July 9, 2020.
[178] Industry representative, interview by USITC staff, June 24, 2020.
[179] In 2019, the UK withdrew from the EU. The high figure for the Netherlands may reflect the large ports of Rotterdam and Amsterdam for delivery of goods for the wider EU market.

Figure 2.5 U.S. exports of dried cranberries to major markets, 2016–19 (million dollars)



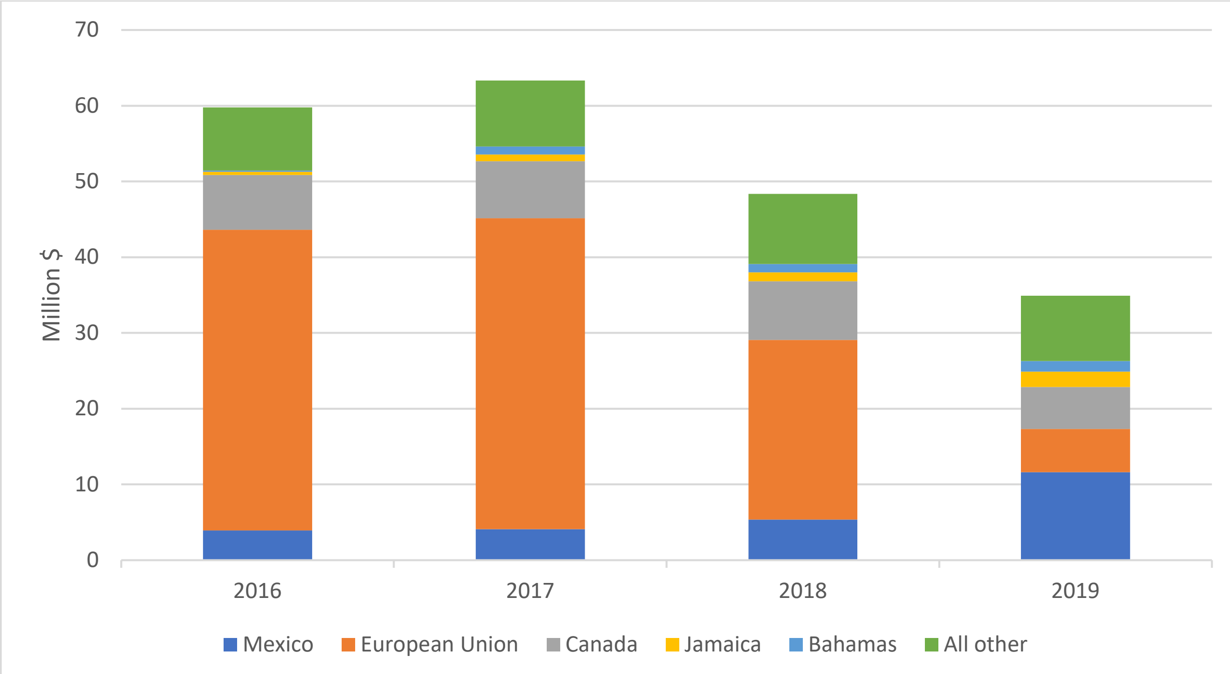
Source: USITC/USDOC DataWeb, HTS 2008.93 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Corresponds to appendix table H.7.

U.S. exports have also increased to several markets in Asia. U.S. exports of dried cranberries to China increased nearly 8-fold between 2012 and 2019 to $39.5 million, despite a 25 percent tariff that China imposed on imports of U.S. dried cranberries in 2018 on top of an existing 15 percent tariff.[180] Exports to other major Asian markets have all increased: U.S. exports of dried cranberries to South Korea increased more than 6-fold between 2012 and 2019 to $10.0 million; exports to Malaysia increased more than 100-fold to $20.0 million; and exports to Hong Kong increased nearly 7-fold during the same period to $7.0 million. According to industry representatives, the rise of major Asian export market demand for cranberries has directed the industry's attention to MRL issues in those key markets and will have implications for MRL compliance.

For the smaller U.S. cranberry juice market, there has been a significant decline in exports between 2012 and 2019. This is driven principally by a substantial decline in exports to the EU due to the 25 percent tariff the EU imposed on cranberry juice in 2018.[181] Between 2012 and 2019, U.S. cranberry juice exports to the EU declined by 89.1 percent, from $53 million to $6 million (figure 2.6), and the EU's share of U.S. exports fell from between 65 and 75 percent of total U.S. cranberry juice exports to less than 16.4 percent in 2019. Other major export destinations for U.S. cranberry juice saw mixed trends: for instance, Mexico gradually increased imports, while imports by Canada experienced some slight declines.[182]

[180] *Wall Street Journal*, "U.S. Cranberry Industry Feels the Bite of Retaliatory Tariffs," August 5, 2018.
[181] In 2018, the EU imposed a 25 percent retaliatory tariff on U.S. exports of cranberry juice concentrate. Karst, "EU Tariffs Begin for Cranberry Juice Concentrate," June 22, 2018.
[182] Canada imposed a 10 percent retaliatory tariff on cranberry juice from the United States in 2018 as well. Karst, "EU Tariffs Begin for Cranberry Juice Concentrate," June 22, 2018.

Figure 2.6 U.S. exports of cranberry juice to major markets, 2016–19 (million dollars)



Source: USITC/USDOC DataWeb, HTS 2009.81 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Corresponds to appendix table H.8.

Pest Pressures and Pesticide Use

The domestic cranberry industry faces a number of pest and disease pressures, including cranberry false blossom disease and a variety of pests whose impact may vary depending on local growing conditions. Both new and emerging pest pressures present substantial yield challenges to growers, especially in wetter parts of the United States. Industry representatives have noted that problems like high humidity and rainfall can create disproportionate pest pressures in New Jersey and Massachusetts in particular.[183] Cranberry growers in the Mid-Atlantic and New England growing regions are particularly affected by cranberry false blossom disease (CFBD), which can cause significant damage and crop loss if uncontrolled. CFBD infects cranberry plants and deforms flowers so that they cannot produce fruit. The disease is spread by the blunt-nosed leafhopper.[184] It was originally discovered in Massachusetts and New Jersey cranberry bogs in 1914–15; it nearly destroyed the cranberry industry in New Jersey in 1928 and severely damaged the Massachusetts and Wisconsin industries.[185]

Historically, the industry has relied on broader-use insecticides such as chlorpyrifos to address the blunt-nosed leafhopper and other problematic insects. However, due to the loss of MRLs and/or of usage registrations for broader-use insecticides like chlorpyrifos in export markets, the cranberry industry has

[183] Industry representative, interview by USITC staff, June 24, 2020.
[184] De Lange, "Blunt-Nosed Leafhopper: A Vector of Cranberry False Blossom Disease," 2018.
[185] One industry representative noted that field losses from an CFBD infestation could constitute a majority of the crop, and in some circumstances could lead to yield losses of 100 percent. USDA, *Yearbook of Agriculture*, 1953, 793; industry representative, interview by USITC staff, July 9, 2020.

increasingly moved to more targeted pesticides to address CFBD.[186] One study noted that “changes in pest management practices, i.e., lower usage of insecticides as well as switching from broad-spectrum insecticides to more target-specific compounds, have caused an increase in populations of blunt-nosed leafhopper in New Jersey cranberries in the last few years.”[187]

In addition, growers are facing challenges resulting from new pests, highlighting the importance to growers of maintaining access to older, broad-spectrum pesticides. For example, a new beetle emerged during the 2019–20 growing season in some Massachusetts bogs. There is currently little information on this pest, which may be a chrysomelid beetle somewhat similar to other beetles that have previously attacked cranberry bogs.[188] This pest, which has been observed eating the tips of cranberry vines, is reportedly slowly spreading throughout Massachusetts cranberry bogs and threatening production there.[189] Given the uncertainties about the nature of this beetle, one industry representative noted that to protect their crop, growers have had to rely on older, broad-spectrum products that cover a wider range of pest pressures than many of the newer, targeted pesticides.[190]

As research continues into the nature of this pest and possible chemical controls, cranberry growers may need to continue relying on older, often more powerful pesticides with usage registrations from several decades ago. Industry representatives state that renewal of MRLs for these older pesticides can be useful in circumstances when a new pest emerges or grows, and more recently developed pesticides cannot resolve the challenge.[191] This emergent pest is an example of how difficult and time-consuming it is for an industry to identify and implement effective pest control strategies and highlights why access to older, broad-spectrum pesticides is important until new, targeted pesticides are developed or IPM systems crafted.[192] In many instances, it can take up to 10 years to bring a new pesticide into the market, making older broad-spectrum pesticides even more critical when new pest challenges emerge.[193]

Costs and Effects of Missing and Low MRLs

The domestic cranberry industry has been negatively affected by low and missing MRLs in export markets. As noted above, the domestic cranberry industry faces substantial pests that are frequently addressed by pesticides. However, MRLs on key insecticides have recently been reduced or are missing in several markets, making it difficult for growers to maintain compliance without suffering yield losses from pest damage. Additionally, with the longer shelf life of processed cranberry products, growers have noted that even potential MRL changes can impact pesticide use. Given that cranberries are frequently blended and segregation by destination market is difficult, growers frequently attempt to grow to the

[186] Industry representative, interview by USITC staff, July 9, 2020.
[187] De Lange, “Blunt-Nosed Leafhopper: A Vector of Cranberry False Blossom Disease,” 2018.
[188] University of Massachusetts Amherst, “IPM Message for Cranberry Growers,” July 12, 2019.
[189] Industry representative, interview by USITC staff, July 9, 2020.
[190] Industry representative, interview by USITC staff, July 9, 2020.
[191] Industry representative, interview by USITC staff, June 24, 2020; industry representative, interview by USITC staff, July 9, 2020.
[192] Industry representative, interview by USITC staff, June 24, 2020; industry representative, interview by USITC staff, July 9, 2020.
[193] For further information on the costs of developing new pesticides, and the implications for growers, see chapter 4 of the first volume of this report.

lowest MRL of a major foreign market, meaning an MRL change in one market can also impact exports destined for less restrictive markets. Finally, as a specialty crop, the cranberry sector can have trouble securing MRLs in Codex or in foreign markets, due to limited registrant interest or data limitations.[194]

Table 2.7 presents the MRLs for several plant protection products that industry representatives noted are of concern in key export markets, including the EU and Japan. These products include a key insecticide (chlorpyrifos), fungicides (mancozeb and chlorothalonil), and an herbicide (quinclorac, used to control invasive grasses) that are of importance to the domestic cranberry industry.

Table 2.7 MRLs for key active ingredients used in the cranberry industry (parts per million)
Some values in cells are marked with footnote letter a, meaning that an MRL is "missing"—it has not been set by the relevant regulatory body.

Active ingredient	Pesticide type	Codex	Canada	United States	Japan	EU	Notes
Chlorpyrifos	Insecticide	1.0	0.1[a]	1.0	1.0	0.01[a]	Approval in the EU not renewed as of December 2019. EU member states' grace periods ended by April 2020, after which MRLs defaulted to 0.01 ppm (previous level was 0.05 ppm).
Chlorothalonil	Fungicide	5.0	2.0	5.0	5.0	0.01[a]	Approval in the EU not renewed as of December 2019. EU member states' grace periods ended by April 2020, after which MRLs defaulted to 0.01 ppm (previous level was 5 ppm).
Mancozeb	Fungicide	5.0	0.1[a]	5.0	5.0	5.0	Next EU review by January 2021.
Quinclorac	Herbicide	1.5	1.5	1.5	2.0	0.0[a]	Canadian MRL is an import tolerance.

Source: Bryant Christie Global, Pesticide MRLs database for active ingredients shown (accessed September 25, 2020).

The potential loss of certain key pesticides for which limited alternatives exist can have a substantial impact on the production and export of U.S. cranberries. Beginning in 2007, the EU began reviewing its authorization of pesticides and their MRLs, and because it did not renew some active substances during this process, the associated MRLs were lowered to the EU default of 0.01 ppm. Others are currently under review.[195] In December 2019, the EU did not renew authorization of the insecticide chlorpyrifos (which, in addition to being used to combat the blunt-nosed leafhopper, can prevent the emergence of certain molds) and the fungicide chlorothalonil. Additionally, the authorization for another major fungicide used by cranberry growers, mancozeb, is up for review in January 2021.

According to industry representatives, if the EU does not reapprove the registration of mancozeb and chlorothalonil, the cranberry industry is concerned about the status of its MRLs, especially for import tolerances. The potential loss of MRLs for these fungicides (both of which can be used to address cranberry fruit rot and other cranberry fungi), as well as the insecticide chlorpyrifos, would have a substantial ripple effect across the U.S. cranberry sector. With chlorothalonil's current default MRL, cranberry growers have largely shifted away from its use in order to continue to export to the EU and other foreign markets.[196] The industry noted that New Jersey and Massachusetts, major cranberry-producing states with significant ongoing pest challenges (particularly fungus pressures in humid

[194] Industry representative, interview by USITC staff, June 24, 2020.
[195] European Commission, "Renewal of Approval" (accessed September 20, 2020).
[196] Cranberry Institute, written submission to USITC, December 11, 2019, 3–10.

climates), could experience as much as a 50 percent reduction in production if faced with the loss of both pesticides. Reportedly, this would translate into a direct loss of 1.2 million barrels of cranberries and into direct sales losses of over $50 million.[197] One cranberry grower in Oregon noted that when he stopped using chlorpyrifos, several insects emerged that contributed a sooty mold infestation, which destroyed the entirety of a year's crop and cost the grower over $33,000.[198]

Processed cranberries and cranberry products often have a longer shelf life than fresh cranberries and other perishable crops. As a result, there is a possibility that an MRL may change between the time the cranberry was grown and the time the processed product is exported or consumed; even a potential reduction or elimination of an MRL can cause changes in grower behavior to prevent MRL violations. The EU renewal process for its existing MRLs has been cited as a particular concern in this regard for the domestic cranberry industry. As noted above, the vast majority of cranberry production and exports is concentrated in dried cranberries and cranberry juice. Both products have a much longer shelf life than fresh cranberries, and cranberry growers have expressed concern that cranberry products made with cranberries grown in compliance with established MRLs in a foreign market may be shipped or sold to that market after that MRL is reduced or set to a low default level. This channels of trade issue has been noted by several growers of processed agricultural products, and is discussed in greater detail in chapter 4 of volume 1 of this report.[199]

For example, cranberry growers stopped using a key fungicide two years in advance of a potential change to EU MRLs. When the U.S. cranberry industry became concerned that the EU would disallow the use of chlorothalonil and lower its cranberry MRL to 0.01 ppm in 2020 or 2021, cranberry growers stopped using the fungicide as early as 2019 due to concerns that dried cranberries or cranberry juice (grown in the 2019 growing season) sold/exported to the EU market two years later could violate the reduced MRL.[200] One industry report notes that the loss of chlorothalonil in a previous period of regulatory approval uncertainty in the EU cost the cranberry industry approximately $20 million in added operating costs and crop losses annually.[201]

Given the substantial blending of cranberries grown in a variety of locations before export, the cranberry industry typically produces cranberries to the lowest MRL of a major U.S. export market. Industry representatives have noted that it is not feasible to tailor pesticide treatments across a large number of bogs to meet distinct export market MRLs.[202] As a result, cranberry growers will reportedly grow to the lowest MRL for each pesticide in order to export to all export markets, even if some export markets have MRLs closer to, or matching, U.S. MRLs. Noting this concern, one industry representative reported that low MRLs for certain key pesticides, notably mancozeb and chlorothalonil in the EU, have required the industry as a whole to adopt a series of alternative pesticides to meet foreign market MRLs, and the representative noted that alternatives are frequently more expensive and less effective.[203]

[197] Cranberry Institute, written submission to USITC, December 11, 2019, 3–10.
[198] Dow, "Who Needs Chlorpyrifos and Why (by Crop)?" 2015.
[199] USITC, "Transition Periods for New MRLs," chapter 4 in volume 1 of this report; Cranberry Institute, written submission to USITC, December 11, 2019.
[200] Cranberry Institute, written submission to USITC, December 11, 2019, 3–10.
[201] Cranberry Institute, written submission to USITC, December 11, 2019, 3–10.
[202] Industry representative, interview by USITC staff, June 24, 2020.
[203] Industry representative, interview by USITC staff, June 24, 2020.

The position of cranberries as a specialty crop presents challenges in the setting and renewal of MRLs. Many pesticides used by cranberry growers in the United States are missing Codex MRLs or have missing or low MRLs in major foreign markets.[204] Multiple industry representatives have noted that because cranberries are a small crop relative to other major agricultural commodities (and even many temperate fruits, like apples), the cranberry sector has found it difficult to secure these MRLs in foreign markets so that growers can use pesticides of prime importance to the industry. Some problems stem from the need to convince potential registrants to invest the resources necessary to collect and submit the necessary data for an MRL application in multiple export markets. The inability to secure needed MRLs in export markets can keep U.S. producers from applying domestically available pesticides that would otherwise be possible crop protection options.[205]

Sweet Cherries

The United States is the second-largest global producer of sweet cherries (after Turkey), with 2019 U.S. production of over $650 million.[206] In contrast to some of the other temperate fruits described in this chapter (like cranberries and tart cherries), the vast majority of U.S. sweet cherries that are exported to foreign markets are in their fresh form. Because of this, MRL violations, which lead to increased inspection and testing as well as port delays, cost growers time and money and can erode the value of this fragile fruit. Additionally, growing pressures from pests, in particular the spotted wing drosophila (SWD), represents a rising challenge for the U.S. sweet cherry sector, as there are lower or missing MRLs for key insecticides used in addressing this fruit fly in certain key export markets, notably the EU. These low and missing MRLs can also contribute to increased costs for U.S. growers by forcing them to use more expensive insecticides, or face reduced yields—and subsequent revenue—if orchards are left untreated.

Industry Overview

The cherry industry in the United States is characterized by substantial production in the Pacific Northwest, with additional production in the Midwest. The United States is one of the world's largest sweet cherry producers and exporters. In contrast to tart cherry production, which is concentrated in Michigan, sweet cherry production is centered in the Pacific Northwest, particularly Washington State, Oregon, and California.[207] In 2019, Washington, Oregon, Idaho, Montana, Utah, and California collectively constituted about 87 percent of total U.S. sweet cherry production, and Washington alone accounted for about 71 percent of production in 2018 and two-thirds of production in 2019.[208]

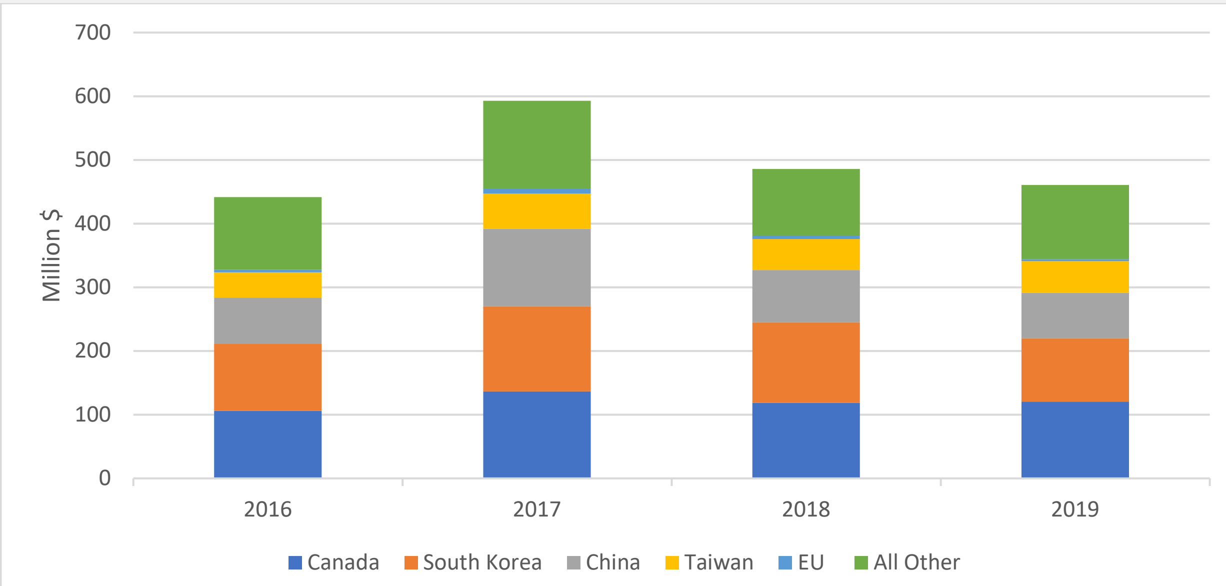
[204] Industry representative, interview by USITC staff, July 9, 2020.
[205] One industry organization noted its ongoing difficulty in securing an MRL in the EU for a commonly used herbicide. This group stated that the EU's current default level for that MRL limits the ability of growers to export treated cranberries to the EU, particularly from states that face heavier pest pressures (New Jersey and Massachusetts). This 12-year process has reportedly cost the industry more than $300,000. Cranberry Institute, written submission to USITC, December 11, 2019, 3–10.
[206] USDA, NASS, "National Statistics for Cherries," 2020.
[207] Northwest Horticultural Council, "Pacific Northwest Sweet Cherries: Cherry Fact Sheet," 2020.
[208] Fruit Grower News, "Forecast Production of Sweet, Tart Cherries," June 11, 2020.

In both domestic and export markets, U.S. sweet cherries are sold largely in their fresh, unprocessed form. Between 2014 and 2019, the value of total fresh sweet cherry production ranged between $619 million and $837 million, far exceeding the value of processed sweet cherries (between $34 million and $61 million). In any given year, the value of fresh sweet cherries can be between 90 and 95 percent of the total value of sweet cherry production in the United States.[209] This contrasts with tart cherries, where value is largely concentrated in processed rather than fresh production.[210]

Trade

In any given year, depending on pricing and crop yield, between 30 and 40 percent of U.S. sweet cherry production may be exported—mainly as fresh cherries, but also some in processed form (dried or in concentrate).[211] In 2019, Pacific Northwestern states accounted for 85 percent of U.S. fresh sweet cherry exports.[212] The largest export markets for U.S. sweet cherries in 2019 were Canada, China, South Korea, Taiwan, Vietnam, and Japan (figure 2.7).[213] Combined, these six markets accounted for more than 85 percent of total U.S. fresh sweet cherry exports.[214]

Figure 2.7 U.S. exports of fresh sweet cherries to major markets, 2016–19 (million dollars)



Source: USITC/USDOC DataWeb, HTS 0809.29 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Corresponds to appendix table H.9.

[209] USDA, NASS, "National Statistics for Cherries," 2020.
[210] USDA. NASS. "National Statistics for Cherries," 2020.
[211] Between 2013 and 2019, the share of sweet cherry exports from the Pacific Northwest ranged from 30.7 percent in 2015 to 35.2 percent in 2017. Northwest Horticultural Council, "Pacific Northwest Sweet Cherries: Cherry Fact Sheet," 2020.
[212] Northwest Horticultural Council, "Pacific Northwest Sweet Cherries: Cherry Fact Sheet," 2020.
[213] Northwest Horticultural Council, "Pacific Northwest Sweet Cherries: Cherry Fact Sheet," 2020.
[214] Northwest Horticultural Council, "Pacific Northwest Sweet Cherries: Cherry Fact Sheet," 2020.

Pest Pressures and Pesticide Use

Over the last 10 years, like many other U.S. fruit crops, both the sweet cherry and tart cherry industries have been dealing with increased insect pressure, particularly from SWD. SWD is an invasive East Asian fruit fly that has been known to attack raspberries, blackberries, blueberries, cherries, and other fruits with thin skins.[215] Unlike other species of drosophila, SWD is known to attack young fruit, consuming it as well as inserting eggs into soft fruit to develop into larvae.[216] The fly takes only three days to mature and hatch—less than half the time of most other fruit flies—allowing for multiple overlapping generations of SWD in the same growing season. Flies can also spread widely, traveling up to 25 miles.[217] Finally, female SWD may introduce fungi while laying eggs, causing larger rot and fermentation in some circumstances.[218]

The consequences of an SWD infestation can be serious for both sweet and tart cherry orchards because it damages fruit as it begins to ripen, causing affected cherries to be entirely unmarketable.[219] This subsequently reduces yields and profitability for growers. In addition to the direct damage SWD can cause to fruit, the introduction of fungi while the parent flies lay their eggs can cause lasting damage to both sweet and tart cherry trees.[220] One study of SWD infestations on fruit crops estimated that yield loss can sometimes be as high as 80 percent.[221]

A few insecticides (including carbaryl, fenpropathrin, malathion, pyrethrin, and spinosad) have been used against SWD infestations in U.S. cherry orchards in addition to IPM programs (described in further detail in the tart cherries case study below). These insecticides are often rotated to prevent pest resistance. However, several face MRL challenges: the EU MRLs for carbaryl and fenpropathrin are set to a default; the EU MRL for malathion is set to 0.02 ppm (99.8 percent lower than the U.S. tolerance); and there is no MRL for pyrethrin in either Codex or Taiwan (table 2.8).

A further problem is that the harvesting season for cherries is brief. As a result, the IPM program for cherry production is highly targeted, and the removal of MRLs or product registrations in key U.S. export markets can significantly disrupt this delicate IPM program. In order to address increasing pest pressures, and recognizing the narrow harvest season for cherries, U.S. sweet cherry growers have identified a few interval-specific pesticide applications to limit the propagation of SWD while meeting MRLs for U.S. export markets. As noted in table 2.8 below, a narrow group of insecticides have been identified as having full or some ability to limit the spread of SWD.[222] However, U.S. cherry growers have to apply these pesticides at pre-harvest intervals of 14 days, 7 days, and 3–4 days in order to meet U.S. and export market MRLs.[223] Since the growing period for cherries is reportedly around 60 days,

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[215] University of Minnesota, "Spotted Wing Drosophila in Home Gardens" (accessed July 15, 2020).
[216] University of Minnesota, "Spotted Wing Drosophila in Home Gardens" (accessed July 15, 2020).
[217] Industry representative, telephone interview by USITC staff, June 8, 2020.
[218] University of Minnesota, "Spotted Wing Drosophila in Home Gardens" (accessed July 15, 2020).
[219] Industry representative, telephone interview by USITC staff, July 8, 2020; Wilson et al., "Managing Spotted Wing Drosophila in Michigan Cherry," July 2019.
[220] Northwest Horticultural Council, "Pacific Northwest Sweet Cherries: Cherry Fact Sheet," 2020.
[221] Bolda, Goodhue, and Zalom, "Spotted Wing Drosophila: Potential Economic Impact," 2010, 5–8.
[222] Washington State University, "Spotted Wing Drosophila" (accessed October 5, 2020).
[223] Industry representative, interview by USITC staff, June 24, 2020; industry representative, interview by USITC staff, July 9, 2020.

identifying these intervals can be difficult.[224] One industry representative reported that a crop picked 2 days later or 2 days earlier than anticipated could create challenges, due either to emergence of SWD (in the former case) or to a remaining residue to address SWD leading to a potential MRL violation (in the latter).[225]

Costs and Effects of Missing and Low MRLs

The U.S. sweet cherry industry has expressed several concerns regarding the potential impact of MRL changes in foreign markets. This is largely because the cost of violating an MRL in an export market can have a long-lasting impact on U.S. grower profitability. As much of the sweet cherry crop produced for the U.S. and foreign markets is sold in its fresh, unprocessed form, quick delivery to retailers is particularly important. Delays that may result from increased testing following an MRL violation can have significant impacts for the whole U.S. sweet cherry industry in an export market.

Cherry growers have also expressed concern that a change to an MRL in a foreign market will disrupt the U.S. sweet cherry IPM program that has been carefully crafted to address new and emerging pest pressures, SWD in particular. Table 2.8 includes MRLs of the key insecticides of concern to U.S. sweet cherry growers, particularly in their efforts to protect their crop from SWD.[226]

Table 2.8 MRLs for key active ingredients used in the sweet cherry industry (parts per million)
Some values in cells are marked with footnote letter a, meaning that an MRL is “missing”—it has not been set by the relevant regulatory body.
n.a. = not applicable

Active ingredient	Pesticide type	United States	Codex	EU	Canada	China	Japan	South Korea	Taiwan	Notes
Buprofezin	Insecticide	2.0	2.0	0.01	2.0	2.0	5.0	1.9	1.5	n.a.
Carbaryl	Insecticide	10.0	n.a.[a]	0.01	10.0	n.a.[a]	10.0	0.5	0.5	EU MRLs amended to default in 2014.
Fenhexamid	Fungicide	10.0	7.0	7.0	6.0	7.0	10.0	5.0	7.0	n.a.
Fenpropathrin	Insecticide	5.0	n.a.[a]	0.01	5.0	5.0	5.0	5.0	5.0	n.a.
Lambda Cyhalothrin	Insecticide	0.5	0.3	0.3	0.5	0.3	0.5	0.3	0.4	n.a.
Malathion	Insecticide	8.0	3.0	0.02	6.0	6.0	6.0	0.5	0.5	In EU, only approved for use in greenhouses.
Pyrethrin	Insecticide	1.0	n.a.[a]	1.0	1.0	n.a.[a]	1.0	1.0	n.a.[a]	n.a.
Spinetoram	Insecticide	0.3	0.9	2.0	1.0	n.a.[a]	0.5	0.2	0.2	n.a.
Spinosad	Insecticide	0.2	0.2	0.2	1.0	0.2	0.2	0.2	0.2	n.a.

Source: Bryant Christie Global, Pesticide MRLs database for active ingredients shown (accessed June 20, 2020).

MRL violations in Taiwan and South Korea, with subsequent increased inspections, illustrate the potential damage of an MRL violation for perishable sweet cherries destined for export markets. In 2016, the U.S. Department of Agriculture was informed by Taiwan’s regulatory authorities that multiple

[224] Industry representative, interview by USITC staff, June 24, 2020; industry representative, interview by USITC staff, July 9, 2020.
[225] Industry representative, interview by USITC staff, June 24, 2020; industry representative, interview by USITC staff, July 9, 2020.
[226] University of Minnesota. “Spotted Wing Drosophila in Home Gardens” (accessed July 15, 2020); industry representative, interview by USITC staff, July 7, 2020.

cherry shipments had violated Taiwan's MRLs for buprofezin (Taiwan MRL 1.5 ppm, U.S. MRL 2 ppm), fenhexamid (Taiwan MRL 7 ppm, U.S. MRL 10 ppm), and fenpropathrin (Taiwan MRL 5 ppm, U.S. MRL 5 ppm).[227] As a result, the normal inspection rate of 2 to 10 percent of shipments was increased to a 100 percent "batch by batch" border inspection of all U.S. cherry shipments.[228] Industry representatives have noted that these delays have reduced the profitability of their product in Taiwan's lucrative market.[229]

A similar development was noted in South Korea. In 2011, an MRL violation was detected for U.S. cherries destined for the South Korean market, and South Korea moved U.S. cherries from its preferential inspection list to an increased testing regime.[230] This meant that between 2011 and 2016, U.S. cherry exports to South Korea experienced additional testing and delays in reaching consumers, despite ongoing compliance with South Korea's MRL obligations.[231] This designation was maintained until April 2017 (in time for the 2017 growing season), when U.S. cherry exports were moved to a lower inspection rate and a document-only review-upon-arrival system.[232]

This type of increased testing proved difficult for U.S. cherry producers; one industry representative noted that the 2011–16 period corresponded with a limited ability to compete in the South Korean cherry market, even though consumers expressed a preference for fresh U.S. cherries, which they considered to be of high quality.[233] During this period, U.S. cherry producers would often reportedly send a few shipments to be tested as early as possible in the growing season to ensure that other shipments could be accepted by the South Korean market after the testing was complete. However, price premiums for cherries are often higher earlier in the season due to consumer interest, meaning testing and subsequent time-to-market delays often occurred during the period when cherries would be most valuable. As a result, South Korean retailers would reportedly discount U.S. cherries for consumers, ultimately reducing the final compensation to U.S. cherry producers.

In addition, given that the vast majority of sweet cherries are sold fresh (rather than as a processed product) and are highly perishable, freshness is a more important attribute for sweet cherries than it is for many other agricultural commodities, and relative freshness is associated with price premiums. One industry representative noted that there can be a 72-hour window between harvesting in California and appearing on a grocery store shelf in Japan.[234] With this turnaround from orchard to consumer (and the narrow harvesting season, approximately 30–40 days), quick testing is important. In certain cases, a sweet cherry shipment may be held at a port for multiple days for testing, significantly degrading the market value of the product.[235]

Industry representatives have noted that maintaining a balance between meeting MRL requirements in multiple markets and addressing pest challenges is proving difficult in practice. One industry representative reported that in some cases, a later-stage risk of SWD emergence before harvest of a

[227] National Horticultural Council, submission to USITC investigation, December 13, 2019, 31–32.
[228] Northwest Horticultural Council, submission to USITC investigation, December 13, 2019, 31–32.
[229] Industry representative, interview by USITC staff, July 7, 2020.
[230] USDA, *U.S. Specialty Crops Trade Issues Report, 2017,* 2018, 11.
[231] USDA, *U.S. Specialty Crops Trade Issues Report, 2017*, 2018, 11.
[232] USDA, *U.S. Specialty Crops Trade Issues Report, 2017*, 2018, 11.
[233] Industry representative, interview by USITC staff, July 7, 2020, 167–70.
[234] Industry representative, interview by USITC staff, July 7, 2020.
[235] Industry representative, interview by USITC staff, July 7, 2020.

cherry crop would likely necessitate the spraying of a product that is no longer permitted in certain export markets, leading to shipments being directed to other export markets.[236] In other cases, a U.S. export destination like Canada, China, the EU, or South Korea can reportedly be so important to the U.S. cherry sector that a default level for a pesticide in one of these markets, or the inability to export commodities treated with that pesticide there, can lead to an industry-wide decision to limit use of that product regardless of export destination.[237]

Tart Cherries

The United States grew $36 million of tart cherries in 2019 and is the fifth-largest producer of tart cherries in the world. Tart cherries are processed into a variety of high-value products before consumption, such as juice and dried cherries, making channels of trade issues problematic for this industry. As with U.S. sweet cherries, SWD has emerged as the industry's main pest issue over the last five years. Responding to this pest pressure results in higher production and export costs. MRL issues in foreign markets, particularly those in the EU, complicates responding to the pest pressure; one insecticide used in controlling SWD is not registered in the EU, while an alternative insecticide that has the same MRL in both the EU and the United States reportedly costs twice as much. Overall, the lack of key insecticide MRLs for SWD in key export markets will likely contribute to yield loss, reductions in U.S. exports of tart cherries, and increased production costs for U.S. tart cherry growers.

Industry Overview

Also known as sour cherries outside of the United States, tart cherries are the fruit of the tart cherry tree *Prunus cerasus.* Unlike sweet cherries, nearly all tart cherries are processed before consumption.[238] Fresh tart cherries can be processed into a variety of forms, including canned, frozen, or dried. Many of these tart cherry products are expensive to produce and therefore are sold as high-value products.[239] The United States is a major producer of tart cherries, with 13,100 tons grown in 2019; Michigan grew 65 percent of the crop, and Utah 20 percent.[240]

Production volumes of tart cherries in the United States can vary widely, leading to variations in supply that, combined with steady demand, can lead to wide swings in prices.[241] To address this, a federal marketing order caps the total volume of tart cherries that can be sold on the domestic market.[242]

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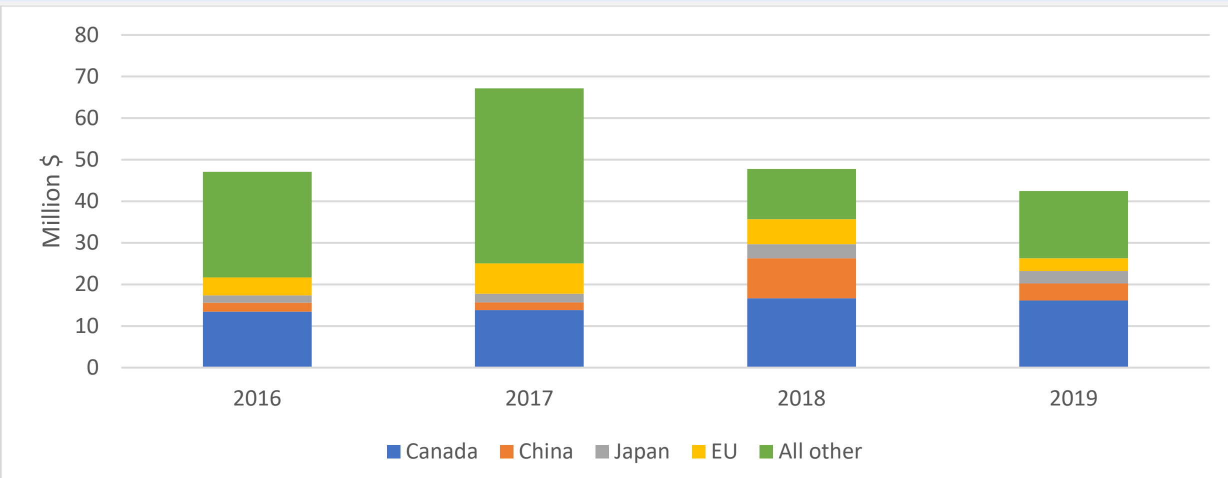
[236] Industry representative, interview by USITC staff, June 24, 2020; industry representative, interview by USITC staff, July 9, 2020.
[237] Industry representative, interview by USITC staff, June 24, 2020; industry representative, interview by USITC staff, July 9, 2020.
[238] Industry representative, telephone interview by USITC staff, June 8, 2020. Sweet cherries are the fruit of *Prunus avium* and are primarily eaten fresh.
[239] Industry representative, telephone interview by USITC staff, July 8, 2020.
[240] By weight, U.S. tart cherry production ranks fifth behind that of Russia, Ukraine, Poland, and Turkey. FAO, FAOSTAT database (accessed May 7, 2020); USDA, NASS, Quick Stats database (accessed May 7, 2020).
[241] "Tart Cherries Grown in the States of Michigan, et al.; Free and Restricted Percentages for the 2018–19 Crop Year and Revision of Grower Diversion Requirement for Tart Cherries," 84 Fed. Reg. 53003, October 4, 2019.
[242] "Tart Cherries Grown in the States of Michigan, et al.; Free and Restricted Percentages for the 2018–19 Crop Year and Revision of Grower Diversion Requirement for Tart Cherries," 84 FR 53003, October 4, 2019.

Trade

Based on the total volume of fresh tart cherry production and the export volume of various tart cherry products, approximately 9 percent of the U.S. tart cherry crop is exported.[243] Because the U.S. marketing order limits the volume of tart cherries that can be sold domestically, exports are an important source of income for the industry. As seen in figure 2.8, 68 percent of U.S. exports of total fresh, frozen, dried, and preserved tart cherry products supply four major export markets: Canada, China, Japan, and the EU. Canada and the EU accounted for 45 percent of total U.S. exports in 2019.

In 2019, fresh tart cherry exports comprised 43 percent of total U.S. tart cherry exports, with China, Japan, and South Korea as the main export destinations.[244] Preserved tart cherries made up 42 percent of total U.S. tart cherry exports in 2019, and dried cherries were 4 percent.[245] The remaining 10 percent of tart cherry exports were exported in frozen form, with 90 percent going to Canada.[246] Although only 2 percent of U.S. frozen tart cherries went to EU markets in 2019, this varies from year to year, depending on the size of the EU crop of tart cherries.[247] For instance, in 2017 and 2018, an average of 40 percent of U.S. frozen tart cherry exports went to EU markets.[248]

Figure 2.8 U.S. exports of fresh, frozen, dried, and preserved tart cherries to major markets, 2016–19 (million dollars)



Source: USITC/USDOC DataWeb, Schedule B 0813403010, 0811908060, 2008600060, 0809210000 (accessed July 27, 2020).
Note on the EU data: United Kingdom (UK) departed the EU in 2019. For purposes of this figure, United Kingdom is included in the EU data throughout the 2016–19 period. Corresponds to appendix table H.10.

[243] USDA, NASS, Quick Stats database (accessed May 7, 2020); USITC/USDOC DataWeb, Schedule B 0813403010, 0811908060, 2008600060, 0809210000 (accessed July 27, 2020).
[244] USITC/USDOC DataWeb, HTS 0809.21.0000 (accessed July 27, 2020).
[245] USITC/USDOC DataWeb, HTS 0813.40.3010 and 2008.60.0060 (accessed July 27, 2020).
[246] USITC/USDOC DataWeb, HTS 0811.90.8060 (accessed July 27, 2020).
[247] USITC/USDOC DataWeb, HTS 0811.90.8060 (accessed July 27, 2020); industry representative, telephone interview by USITC staff, July 8, 2020.
[248] In 2017, EU markets accounted for 42 percent of U.S. frozen tart cherries; in 2018, for 37 percent. USITC/USDOC DataWeb, HTS 0811.90.8060 (accessed July 27, 2020).

Pest Pressures and Pesticide Use

The emergence of new pests, coupled with ongoing difficulties in producing tart cherries, is creating MRL compliance challenges for U.S. growers. Tart cherry production is highly variable,[249] owing mainly to weather and pest pressure. Devastating late frosts in Michigan occurred in 2002 and 2012 that wiped out nearly the entire the crop.[250] In 2020, there was a late freeze in Michigan, and as a result, in several growing areas, growers reportedly will not try to harvest this year.[251]

In addition, SWD, as noted above, has emerged over the last five or so years as the main pest impacting both tart and sweet cherries. The impact of SWD on tart cherry production, and thus its cost, varies across the United States and growing seasons. For tart cherries there is more SWD pressure in Michigan, with its cooler and wetter climate, than in Utah, where it is hotter and drier.[252] According to an industry representative, growers typically need to make two or three applications of insecticides for SWD per season in northern Michigan, while only one application is needed in central Michigan, and growers in southern Michigan might not have to apply any insecticides to control SWD.[253] The pressure from SWD also varies across growing seasons, with growers in Michigan reporting up to 20 percent of the crop damaged from SWD in 2016 and 2017, and then minimal damage in the hot, dry season of 2018.[254] According to industry representatives, 16–20 percent of production was again lost to SWD in 2019.[255]

Managing SWD requires constant monitoring and proactive applications of pesticides, which in turn raises the cost of production and reduces profit margins.[256] Often the application of pesticides is the most effective means to address this emerging pest. While there are a few cultural practices that may make orchards less conducive to SWD, such as pruning trees to allow more light and airflow through the trees, and keeping the grass below the trees mowed low to allow more airflow, the application of insecticides is the only truly effective method of SWD control.[257] Since the exact harvest time for tart cherries depends on weather conditions, and because SWD damages ripening fruit, a pesticide's pre-harvest interval (PHI)—the required time between the application of a pesticide and when the crop can be harvested—is an important consideration in tart cherry orchard management. In this situation a shorter PHI is better, as it allows for SWD control closer to a variable harvest date.

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[249] USDA, NASS, Quick Stats database (accessed May 7, 2020); industry representative, telephone interview by USITC staff, July 8, 2020; Milkovich, "'Three Pillars' Uphold the Tart Cherry Industry," December 4, 2015.
[250] Payette, "Michigan's Tart Cherry Orchards Struggle to Cope," April 7, 2017.
[251] Industry representative, telephone interview by USITC staff, July 8, 2020; Manning, "Bad year? Try being a Cherry Farmer," August 22, 2020.
[252] Initial research has shown that SWD prefers higher relative humidity and moderate summer temperatures; adult activity as well as egg laying begins to decrease when temperatures rise above 86 degrees Fahrenheit. Industry representative, telephone interview by USITC staff, July 8, 2020; Wilson et al., "Managing Spotted Wing Drosophila in Michigan Cherry," July 2019.
[253] Industry representative, telephone interview by USITC staff, July 8, 2020.
[254] Rothwell, Pochubay, and Powers, "Spotted Wing Drosophila Numbers in Cherries Called 'Startling,'" July 16, 2018; Mertz, "Making Orchards Less Hospitable for SWD," May 21, 2019.
[255] Industry representative, telephone interview by USITC staff, July 8, 2020.
[256] Longstroth, "Plan to Change when Dealing with Spotted Wing Drosophila," June 28, 2017; Prengaman and Courtney, "Tart Growers Target Turkey," June 6, 2018.
[257] Mertz, "Making Orchards Less Hospitable for SWD," May 21, 2019; industry representative, telephone interview by USITC staff, July 8, 2020.

The added costs of production due to the need to control SWD come at a time of falling prices. Since 2014, the value of tart cherry production has fallen by two-thirds.[258] This has worsened conditions for an industry with already tight margins. According to an industry representative, it costs $1,400 an acre to grow tart cherries, but a grower in recent years reported only $1,100 per acre in revenue.[259] These losses reportedly have led some growers to abandon their orchards.[260]

In addition, the abandonment of cherry orchards can increase pest pressure for remaining growers in nearby areas. Trees in abandoned orchards still bear fruit that is then infested with SWD. The uncontrolled SWD populations in abandoned or unharvested orchards add increased pressure and costs on the operational orchards.[261] Industry representatives expressed concern that this issue will complicate the 2020 harvest, because some growers reportedly did not harvest this summer's small crop after a devasting late frost that, combined with SWD damage, made it uneconomical to harvest.[262]

Costs and Effects of Missing and Low MRLs

Controlling SWD adds to production costs, and low and missing MRLs make this more complicated and costly. The U.S. tart cherry industry is attempting to find methods of controlling SWD, with various industry organizations spending over $1.4 million for SWD research since 2015.[263] There are reportedly only a few insecticides available that can control SWD, and new insecticides can often be expensive or lack MRLs in export markets.[264] The applications of different insecticide products vary in costs per acre, and each comes with different MRL implications, as seen in table 2.9. An insecticide may be important to growers because it has a short PHI, allowing the grower to control for SWD close to the harvest date, which is variable and hard to predict.[265] However, if an important export market has a low MRL, growers will not be able to take advantage of the insecticide's low PHI.[266]

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[258] USDA, NASS, Quick Stats database (accessed May 7, 2020).
[259] Industry representative, telephone interview by USITC staff, July 8, 2020.
[260] Industry representative, telephone interview by USITC staff, July 8, 2020.
[261] Industry representative, telephone interview by USITC staff, July 8, 2020.
[262] Industry representative, telephone interview by USITC staff, July 8, 2020; Manning, "Bad year? Try being a Cherry Farmer," August 22, 2020.
[263] Industry representative, telephone interview by USITC staff, June 8, 2020; industry representative, telephone interview by USITC staff, July 8, 2020; industry representative, email message to USITC staff, July 22, 2020.
[264] Industry representative, telephone interview by USITC staff, July 8, 2020.
[265] Industry representative, telephone interview by USITC staff, June 8, 2020; industry representative, telephone interview by USITC staff, July 8, 2020.
[266] Industry representative, telephone interview by USITC staff, June 8, 2020; industry representative, telephone interview by USITC staff, July 8, 2020.

Table 2.9 MRLs for key active ingredients used in the tart cherry industry (parts per million)
Some values in cells are marked with footnote letter a, meaning that an MRL is "missing"—it has not been set by the relevant regulatory body. Others are marked with footnote letter b, meaning that an MRL is set to that market's default value (usually a very low MRL). If a cell value is marked with footnote letter c, that means the MRL is "temporary," i.e., it is pending further regulatory review.
n.a. = not applicable

Active ingredient	Pesticide type	United States	Codex	EU	Canada	Japan	South Korea	China	Taiwan
Fenpropathrin	Insecticide	5.0	n.a.[a]	0.01[b]	5.0	5.0	5.0	5.0	5.0
Cyantraniliprole	Insecticide	6.0	6.0	6.0	6.0	6.0	6.0	6.0[c]	0.01[b]
Zeta-cypermethrin	Insecticide	1.0	2.0	2.0	0.1[b]	2.0	1.0	2.0	0.01[b]

Source: Compiled by USITC, using Lexagri International, Homologa database (accessed multiple dates).

In order to address these pest challenges and comply with foreign market MRLs, growers often must incur higher costs and use less effective products. A product called Danitol, an insecticide formulated with fenpropathrin, costs $25 per acre per application.[267] In the United States, this product has a three-day PHI, meaning that a grower can apply it no later than three days before harvest.[268] As seen in table 2.9, fenpropathrin has a 5 ppm MRL on tart cherries in the United States, but is not approved for use in the EU, resulting in a 0.01 ppm default MRL.[269] In order to avoid violating this low default MRL in the EU, growers in the United States cannot use the product within one month of harvest, regardless of the three-day PHI in the United States, which effectively limits its utility in preventing SWD infestation as the fruit ripens.[270] As a result, industry representatives report that this product is not used on tart cherries that may be shipped to the EU.[271]

Even though some pesticides effective at combating SWD are approved in export markets, they may be costly, and their effectiveness may be undermined by low MRLs. A new product called Exirel, containing the active substance cyantraniliprole, is approved by the EU. It has the same 6 ppm MRL in the EU as in the United States, and has a three-day PHI as well.[272] However, it costs $50 per acre per application, and may violate the applicable MRL in Taiwan of 0.01 ppm if used within one month of harvest.[273] Another relatively new product called Mustang Maxx has a labeled PHI in the United States of 14 days on tart cherries, but the industry has secured a Federal Insecticide Fungicide and Rodenticide Act (FIFRA) Section 24C, Special Local Needs Label in Michigan allowing a three-day PHI.[274] This allows growers to use this product to protect the cherry crop against SWD up to three days before harvest. It reportedly costs just under $25 per acre per application.[275] The active substance, zeta-cypermethrin, has

[267] Industry representative, telephone interview by USITC staff, July 8, 2020.
[268] Wilson et al., "Managing Spotted Wing Drosophila in Michigan Cherry," July 2019.
[269] Lexagri International, Homologa database (accessed July 15, 2020).
[270] Wilson et al., "Managing Spotted Wing Drosophila in Michigan Cherry," July 2019.
[271] Industry representative, email message to USITC staff, August 3, 2020.
[272] Lexagri International, Homologa database (accessed July 15, 2020); Wilson et al., "Managing Spotted Wing Drosophila in Michigan Cherry," July 2019.
[273] Industry representative, telephone interview by USITC staff, July 8, 2020; Wilson et al., "Managing Spotted Wing Drosophila in Michigan Cherry," July 2019.
[274] A FIFRA Section 24C, Special Local Needs Label allows states to register and set residue levels for pesticides that are not currently available in response to an existing or imminent pest issue. Rothwell et al., "Managing Spotted Wing Drosophila in Cherries at Harvest Time," July 12, 2017.
[275] Industry representative, email message to USITC staff, July 30, 2020.

a 1 ppm MRL in the United States, a 2 ppm MRL in the EU, and a 0.1 ppm default MRL in Canada.[276] However, industry representatives report using the standard 14-day PHI due to concerns that the three-day emergency PHI will result in the active ingredient, zeta-cypermethrin, violating the applicable MRLs in the EU, Canada, and other key export markets.[277]

In order to comply with MRLs, industry handlers, such as cooperatives and marketing companies, have developed programs detailing what pesticides growers should use, at what quantities, and at what time prior to harvest for each market. The industry handlers work with growers to designate certain orchards to use growing practices that allow them to meet the MRLs in the target market. If pest pressure is too high to allow an orchard to meet the MRLs in the target market with the most restrictive MRLs, then they designate the product from that orchard for an export market with less restrictive MRLs. If the crop in an orchard can meet the MRLs in a target market, then that product is segregated from crops intended for other markets.[278] This is reportedly easier for some handlers than others and can depend on the number of growers and size of the handling firm. Production practices that will meet EU MRLs reportedly add $130 in costs per acre—reportedly similar to the added cost of growing organic cherries, but without the marginal price premium for organic.[279]

In order to ensure compliance, handlers will often conduct expensive pre-export tests. According to one industry representative, one residue test for tart cherries reportedly costs $500, including the cost of shipping.[280] Additionally, a single tart cherry handler will reportedly conduct an estimated 300 residue tests per year, adding significant compliance costs.[281] To successfully sell tart cherries into the EU market, a firm reportedly has to test after harvest, test again after processing, and conduct another test on arrival in the EU. The first customer in the EU may then sell it to another customer, who may very well require another test. If the product passes all the prior tests but fails the final test, the product still faces rejection. Some companies along the supply chain will allow another test to be conducted in case of a failed test, but that is not always the case.[282]

Beyond MRL regulations, private company concerns about pesticides represent an additional hurdle to U.S. tart cherry exports. In 2017, a tart cherry firm had a shipment of individually quick frozen cherries rejected by an EU customer.[283] The firm had a contract for 334,000 pounds of frozen tart cherries for $0.84 per pound with a certificate from Eurofins, a laboratory testing company headquartered in Luxembourg, indicating MRL compliance. When the shipment of cherries arrived in the EU, the customer had the frozen tart cherries tested at a different laboratory, which showed MRL compliance. Regardless, the intended EU customer refused the shipment of cherries, citing "too many chemicals" in the test results from the other laboratory, ending the contract, and forcing the U.S. firm to

[276] Lexagri International, Homologa database (accessed multiple dates).
[277] Industry representative, telephone interview by USITC staff, June 8, 2020; industry representative, email message to USITC staff, August 3, 2020.
[278] Industry representative, telephone interview by USITC staff, June 8, 2020.
[279] Industry representative, telephone interview by USITC staff, July 8, 2020.
[280] Industry representative, telephone interview by USITC staff, July 8, 2020.
[281] Industry representative, telephone interview by USITC staff, July 8, 2020.
[282] Industry representative, telephone interview by USITC staff, July 8, 2020.
[283] Industry representative, telephone interview by USITC staff, July 8, 2020; industry representative, email message to USITC staff, July 30, 2020.

quickly find another buyer.[284] While another buyer was being lined up, the firm incurred cold storage costs for the frozen cherries. In addition, because the shipment had been rejected, the only buyer that could be found paid only $0.14 per pound, a loss of $232,560 on the shipment.[285]

Sweet Potatoes

The United States is the largest global exporter of sweet potatoes, with annual production valued at $588 million in 2019. Fungal diseases are a major concern for the U.S. sweet potato industry, as they reduce yields. While the U.S. industry relies heavily on cultural methods of control, such as crop rotation, fungicides provide additional options to control fungal disease. Export markets are an important source of revenue to the industry, providing up to six times the returns offered by the domestic market. However, low and missing MRLs in export markets, particularly the EU, offer growers a choice: either they can choose to bear the cost of complying with low or missing MRLs through use of alternative pesticides which may be less effective and more expensive (if they are available at all), raising production costs and reducing yields, or they can choose not to comply, which results in the loss of export markets.

Industry Overview

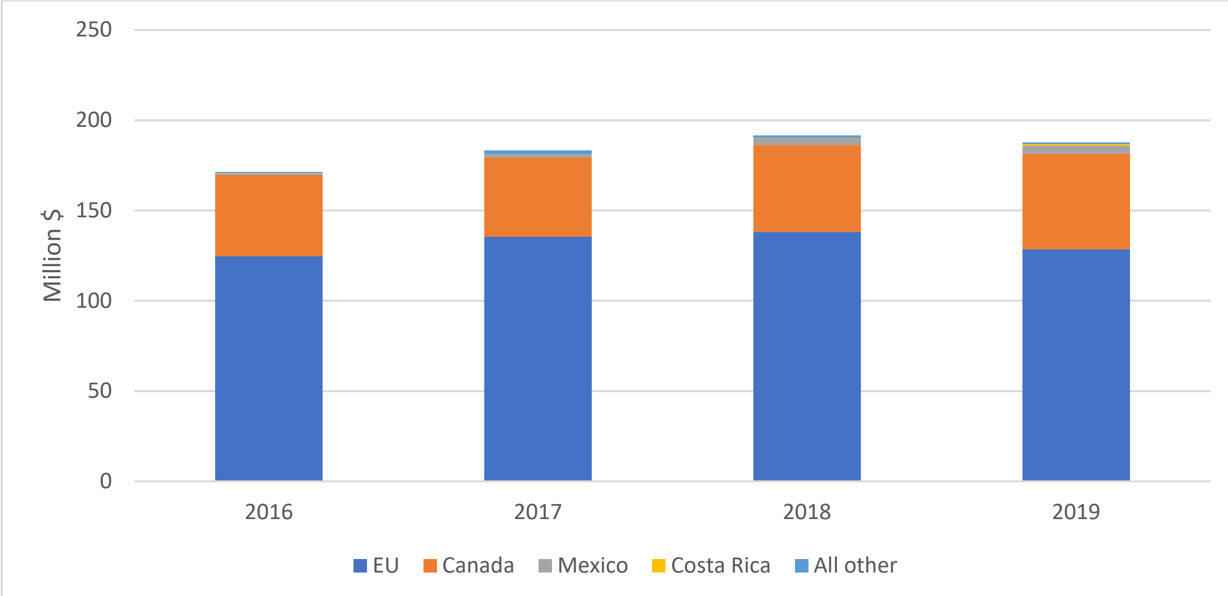
Sweet potatoes are the roots of a tropical vine in the morning glory family that can have orange or white sweet flesh.[286] As a tropical plant, sweet potatoes grow well in places with long, hot summers.[287] In 2019, the United States grew 1.8 million tons of sweet potatoes, largely in North Carolina, which is the center of U.S. sweet potato production and accounted for over 60 percent of the total U.S. crop.[288] Other major sweet potato U.S. production states include California and Mississippi.[289]

Trade

Approximately 18 percent of the U.S. crop was exported in 2019, with 40 percent of North Carolina production exported.[290] As seen in figure 2.9, on average over the last three years, 70 percent of U.S. exports of sweet potatoes were shipped to the EU. These shipments were valued at nearly $130 million and represented nearly a quarter of industry revenue.[291]

[284] Industry representative, email message to USITC staff, July 30, 2020.
[285] Industry representative, telephone interview by USITC staff, July 8, 2020; industry representative, email message to USITC staff, July 30, 2020.
[286] Agricultural Marketing Resource Center, "Sweet Potatoes," August 2018. In contrast, white potatoes are swollen stems of a plant in the nightshade family.
[287] Agricultural Marketing Resource Center, "Sweet Potatoes," August 2018.
[288] USDA, NASS, Quick Stats database (accessed August 4, 2020); ASPMI and U.S. Sweet Potato Council, written submission to the USITC, December 13, 2019, 1.
[289] USDA, NASS, Quick Stats database (accessed August 4, 2020).
[290] USDA, NASS, Quick Stats database (accessed August 4, 2020); ASPMI and U.S. Sweet Potato Council, written submission to the USITC, December 13, 2019, 1; USITC/USDOC DataWeb, Schedule B 0714.20 (accessed July 27, 2020).
[291] USITC/USDOC DataWeb, Schedule B 0714.20 (accessed July 27, 2020); USDA, NASS, Quick Stats database (accessed August 4, 2020).

Figure 2.9 U.S. exports of sweet potatoes to major markets, 2016–19 (million dollars)



Source: USITC/USDOC DataWeb, Schedule B 0714.20 (accessed July 27, 2020).
Note on the EU data: The United Kingdom (UK) departed the EU in 2019. For purposes of this figure, the United Kingdom is included in the EU data throughout the 2016–19 period. Corresponds to appendix table H.11.

Pest Pressures and Pesticide Use

Fungal diseases are a major concern for the U.S. sweet potato industry, along with nematodes and insect larva. The industry relies primarily on cultural methods, such as crop rotation, to control pests and diseases.[292] Over the past 6 years, however, the industry has reportedly reduced its reliance on cultural controls from approximately 95 percent of total pest and disease control measures to about 80 percent. During this time, the industry has increasingly incorporated the use of pesticides at planting to reduce volatility in marketable yield.[293] In the past, farmers considered pesticides to be an expensive alternative to cultural controls, but increasingly IPM systems that incorporate pesticides are relied on by the industry in recognition of the fact that a combination of cultural and chemical controls achieves better results than either one alone.

Black rot is a major disease concern for the industry and has reportedly surged since 2014.[294] While black rot frequently starts in the field, it is often not apparent until after harvest and is therefore treated as a post-harvest disease. The fungus that causes black rot, *Ceratocystis fimbriata*, can be spread at essentially any stage of production, including post-harvest handling. This disease leaves dark lesions on the sweet potato and produces toxins, making the product unmarketable and unfit for human or animal

[292] Academic professional, telephone interview by USITC staff, July 7, 2020.
[293] ASPMI and U.S. Sweet Potato Council, written submission to the USITC, December 13, 2019, 5; academic professional, telephone interview by USITC staff, July 7, 2020.
[294] ASPMI and U.S. Sweet Potato Council, written submission to the USITC, December 13, 2019, 3; academic professional, telephone interview by USITC staff, July 7, 2020; academic professional, email message to USITC staff, August 21, 2020; Clark and Smith, "Black Rot of Sweet potato," February 2016.

consumption.[295] It infects a sweet potato through open wounds in the skins, so minimizing damage during and after harvest is an important preventative technique.

Fungicidal control of black rot is complicated by low MRLs in export markets as well as by the cost and effectiveness of the products. The fungicide Mertect, containing the active substance thiabendazole, is reportedly a highly effective method of black rot control, but faces a low default MRL in the EU, the main export market for U.S. sweet potatoes. An alternative fungicide for controlling black rot is Stadium. This newer product was registered in the United States in 2019 and is reportedly four times as expensive as Mertect.[296] This is partly because it was originally developed for the larger white potato industry, which had seven times more revenue in 2019 than the sweet potato industry.[297] Stadium has three active ingredients—difenoconazole, fludioxonil, and azoxystrobin—making it effective at controlling multiple diseases, including those caused by the fungus *Rhizopus*. However, it is not as effective as Mertect at controlling black rot, and also faces low MRLs in export markets.[298]

Another post-harvest fungus, *Rhizopus*, is addressed with fungicide controls. Preventing damage to the sweet potato and managing temperature and humidity post-harvest are preventative control methods for this fungus that causes soft rot. However, use of chemical controls is also key, especially for participation in export markets, because there is a longer time to market during which the product can rot. While some organic producers have reportedly been using rubbing alcohol for post-harvest control of *Rhizopus*, this only helps control the fungus for a week, which is too short for exported products. Fungicides can provide longer periods of control that can allow for products to be exported. There are several options, including fungicides that contain fludioxonil. However, they are not considered as effective, and reportedly they are three times the price of the alternative, Stadium.[299] Stadium is more effective at controlling *Rhizopus* because it has three active ingredients that can each control the fungus.[300]

Sweet potatoes are also susceptible to nematodes and insect larvae. Root knot nematodes, which are primarily spread to fields through contaminated seed slips, stunt the plant and deform the sweet potato.[301] This results in yield loss and unmarketable products. Crop rotation provides some control. The main chemical control for nematodes used to be fumigants. However, since many of the most effective and thus harshest fumigants, like methyl bromide, have been phased out due to serious health and environmental concerns, pressure from nematodes has increased.[302] Pesticide manufacturers have developed some nematicide products that can work in tandem with strict cultural practices.[303] In

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[295] Clark and Smith, "Black Rot of Sweet potato," February 2016.
[296] Academic professional, telephone interview by USITC staff, July 7, 2020.
[297] Academic professional, telephone interview by USITC staff, July 7, 2020; academic professional, email message to USITC staff, August 21, 2020; USDA, NASS, Quick Stats database (accessed September 21, 2020).
[298] Academic professional, telephone interview by USITC staff, July 7, 2020.
[299] Academic professional, telephone interview by USITC staff, July 7, 2020; academic professional, email message to USITC staff, August 21, 2020.
[300] Academic professional, telephone interview by USITC staff, July 7, 2020; academic professional, email message to USITC staff, August 21, 2020.
[301] Quesada-Ocampo, "Sweet potato Root Knot Nematode," May 24, 2018.
[302] Academic professional, telephone interview by USITC staff, July 7, 2020; academic professional, email message to USITC staff, August 21, 2020.
[303] Academic professional, telephone interview by USITC staff, July 7, 2020; academic professional, email message to USITC staff, August 21, 2020.

addition, wireworms, the larvae of various species of click beetles,[304] eat round holes in the sweet potato, rendering it unmarketable.[305] The primary method of control is with cultural practices due to growers' limited ability to apply insecticides in the soil, since sweet potatoes grow underground.[306] Chlorpyrifos is the only effective insecticide for controlling wireworms.[307]

As with many crops, there is a high degree of volatility in sweet potato production, much of it stemming from pest and disease pressure. Incorporating pesticides into the IPM system has allowed the sweet potato industry to reduce some of that volatility. Without a fungicide application at planting, the typical loss is 30 to 40 percent of the crop, but with a fungicide the loss is just 5–10 percent.[308]

Costs and Effects of Missing and Low MRLs

Fungicide MRLs are particularly important for the sweet potato industry, since fungal diseases are the biggest pest issues affecting growers. Several key pesticides used by the sweet potato industry face low and missing MRLs in export markets (table 2.10), creating compliance challenges for growers as they address pest pressures while trying to export to lucrative foreign markets. The low and missing MRLs in table 2.10 undermine the ability of the U.S. sweet potato industry to take full advantage of export opportunities in several export markets, particularly the EU (which accounts for approximately 70 percent of U.S. sweet potato exports). These export markets can be highly profitable for growers: reportedly, in certain export markets a 5-pound bag of sweet potatoes can sell at a price six times higher than in the domestic market.[309] Despite export market demand, growers cannot always guarantee quality to their customers because MRL compliance concerns constrain the industry's post-harvest options. These factors ultimately limit growers' ability to access these markets.[310]

Table 2.10 MRLs for key active ingredients used in the sweet potato industry (parts per million)
Some values in cells are marked with footnote letter a, meaning that an MRL is "missing"—it has not been set by the relevant regulatory body. Others are marked with footnote letter b, meaning that an MRL is set to that market's default value (usually a very low MRL). For cells marked with footnote letter c, Costa Rica MRLs are set to a default of the United States MRL.
n.a. = not applicable

Active ingredient	Pesticide type	United States	EU	Canada	Codex	Costa Rica
Thiabendazole	Fungicide	10.0	0.01	0.1[b]	n.a.[a]	10.0[c]
Difenoconazole	Fungicide	4.0	0.1	4.0	n.a.[a]	4.0[c]
Fludioxonil	Fungicide	6.0	10.0	6.0	10.0	10.0
Azoxystrobin	Fungicide	8.0	1.0	8.0	1.0	1.0
Chlorpyrifos	Insecticide	0.05	0.01	0.1[b]	n.a.[a]	0.05

Source: Compiled by USITC, using Lexagri International, Homologa database (accessed multiple dates).

The removal of the EU MRL on thiabendazole, a key fungicide used to control black rot, is the largest MRL issue faced by the industry. In the United States, the MRL for use of thiabendazole, the most

[304] There are several species of click beetles. Some are considered pests, and some considered beneficial.
[305] Gannon, "Wireworms: Hidden Pests in Sweet Potato Fields," September 19, 2017.
[306] Gannon, "Wireworms: Hidden Pests in Sweet Potato Fields," September 19, 2017.
[307] Academic professional, telephone interview by USITC staff, July 7, 2020; ASPMI and U.S. Sweet Potato Council, written submission to USITC, December 13, 2019, 3.
[308] Academic professional, telephone interview by USITC staff, July 7, 2020.
[309] Academic professional, telephone interview by USITC staff, July 7, 2020.
[310] Academic professional, telephone interview by USITC staff, July 7, 2020.

effective fungicide for containing black rot, on sweet potatoes is 10 ppm. However, the EU revised the MRLs on several products for this active substance in January 2018, and the MRL for thiabendazole on sweet potatoes was lowered to the default MRL of 0.01 ppm.[311] This low level precludes the use of fungicides containing thiabendazole for product exported to the EU. To address this challenge, the registrant submitted a data package in February 2019 to adjust the MRL. The EU subsequently requested metabolite data, and the application is still under review. In the meantime, the EU's low default MRL of 0.01 ppm is reportedly hindering sweet potato exports from the United States to the industry's largest export market.[312]

Stadium is an alternative fungicide used for both black rot and *Rhizopus*, but the three active ingredients in this product triples the number of MRLs that must be complied with in each market that the product is sold. Two of the active ingredients, difenoconazole and azoxystrobin, face low or missing MRLs in various export markets—including the EU, the industry's largest export market. U.S. growers are particularly concerned that, even if used according to the approved U.S. label, azoxystrobin will violate the EU MRL.[313] As a result, growers are forced to choose between using less effective and potentially more expensive products that raise costs and reduce yields in order to comply, or forgoing export markets with higher revenues when they use products for which MRLs are missing or low. Low and missing MRLs for products to address other post-harvest developments that impact product quality, like sprouts, can also impact the export of a number of U.S. agricultural products, such as potatoes (box 2.1).

[311] European Commission, Commission Regulation (EU) 2017/1164, 2017.
[312] Academic professional, telephone interview by USITC staff, July 7, 2020.
[313] Academic professional, telephone interview by USITC staff, July 7, 2020; academic professional, email message to USITC staff, August 21, 2020.

Box 2.1 Potato MRL Violations: Sprout Inhibitor in South Korea

In January 2018, the U.S. potato industry had an MRL violation stemming from a missing MRL in South Korea, a $110 million market for the U.S. potato industry.[a] The violation derived from a shipment of fresh potatoes that was treated with a sprout inhibitor 2,6-Diisopropylnaphthalene (2,6-DIPN), which prevents the potato from sprouting while in storage.[b] 2,6-DIPN was applied to a 60-load shipment of chipping potatoes,[c] valued at approximately $780,000, that was sold to a South Korean food manufacturer for further processing into potato chips.[d] At that time, before the country had established its positive list system, South Korea did not have an MRL established for 2,6-DIPN, and deferred to the Codex MRL, which was also missing.[e] The applicator did not check the MRL in the export market, and the grower was also unaware the MRL was missing. When tested on arrival in South Korea, the shipment was found to be in violation.[f]

The U.S. potato industry, through the United States Embassy in Seoul, argued that because MRLs are typically set on the raw agricultural product, the South Korean government should retest the potatoes after processing into potato chips. Since processing raw agricultural products can often reduce the residues through peeling, rinsing, or heating, such "processing factors" can be considered in these situations. After a month of discussions and with the potatoes sitting in storage, the South Korean government rejected the shipment of potatoes.[g]

Some of the rejected shipment was reportedly sold in other markets in the region, but the vast majority of the shipment was destroyed.[h] The shipper was also liable for a number of fees, including demurrage (a charge for not unloading a cargo ship in time) and additional transportation, as well as destruction fees.[i] The impact was not limited to the South Korean market. When a chip processor in Japan (the U.S. potato industry's most valuable export market, valued at nearly $350 million per year) learned of the South Korea violation, they requested that a shipment of 15 containers (at an approximate value of $200,000) be tested. Despite initial testing of the first shipment showing compliance with Japanese MRLs, the importers denied the entire shipment out of concern that it was too close to violating the MRL, and refused shipment of the remaining 10 million pounds in the contract, valued around $2.4 million. The shipper subsequently sent the 10 million pound shipment back to the United States, where they were sold at reduced prices in the domestic market.[j]

[a] Industry representative, email message to USITC, July 14, 2020; NPC, written submission to USITC, December 13, 2019, 13; industry representative, telephone interview by USITC staff, July 13, 2020.
[b] Industry representative, telephone interview by USITC staff, July 13, 2020.
[c] "Chipping" potatoes are potatoes that are used for french fry and potato chip processing.
[d] Industry representative, email message to USITC, July 14, 2020; NPC, written submission to USITC, December 13, 2019, 13.
[e] Industry representative, telephone interview by USITC staff, July 13, 2020; NPC, written submission to USITC, December 13, 2019, 13.
[f] NPC, written submission to USITC, December 13, 2019, 13.
[g] NPC, written submission to USITC, December 13, 2019, 13.
[h] Industry representative, email message to USITC, July 14, 2020.
[i] Demurrage is a shipping fee paid when the cargo is not loaded or unloaded on schedule. Industry representative, email message to USITC, July 14, 2020.
[j] Industry representative, email message to USITC, July 14, 2020.

The sweet potato industry in the United States is also concerned about potential future MRL issues that can remove effective control options for nematodes and wireworms.[314] So far, nematicides have not been impacted by MRL policy shifts or changes, but if one of those products were impacted by low

[314] Academic professional, telephone interview by USITC staff, July 7, 2020; academic professional, email message to USITC staff, August 21, 2020.

or missing MRLs, it would have a significant impact on growers in every sweet potato-producing state in the United States. Another concern for the industry involves the phasing out of chlorpyrifos, the only effective product for wireworm control. Chlorpyrifos is being phased out in several states, such as California, and in export markets, including the EU. Growers are concerned about the status of these MRLs, since wireworms leave their crop unmarketable and can be difficult to control with cultural methods alone.[315]

Edible Nuts

The United States is the world's leading producer of almonds and pistachios. These edible nuts are an important U.S. agricultural export, worth over $7 billion in 2019. U.S. edible nut industries have spent decades and millions of dollars battling a pest, the navel orangeworm, which spreads the fungus that produces aflatoxin, a fungal toxin dangerous to human health. To control navel orangeworm, the industry created an IPM program which includes the use of certain key pesticides. However, certain key U.S. export markets have begun to remove the registrations for some of these pesticides and then to lower the MRLs associated with those pesticides. There are concerns within the nut sectors that some important pesticides that farmers rely on may face increasing scrutiny in these markets and as a result may lose MRLs in those markets. The industries report that if those tools are lost, their IPM programs will be disrupted with little time to adjust, requiring them to choose between losing access to some of the most important export markets or facing potential increases in the prevalence of aflatoxin.

Industry Overview

California produces nearly all of the U.S. commercial almond crop, and almonds are among California's largest agricultural commodities in terms of value, reaching over $6 billion in 2019.[316] Pistachios are also among the top five agricultural commodities in California, valued at over $1.9 billion.[317] More than half of California's almond and pistachio production is grown on smaller farms of less than 100 acres.[318]

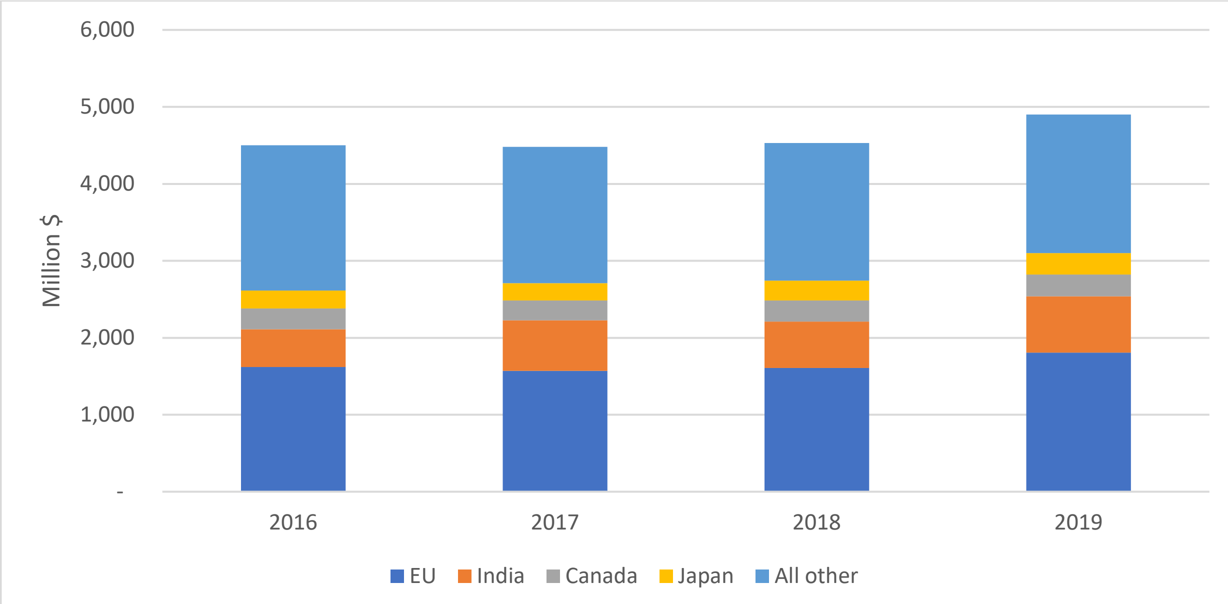
Trade

U.S. exports of almonds and pistachios were valued at nearly $7 billion in 2019.[319] Almonds accounted for more than half of these exports. The United States is the world's largest producer of almonds, producing over 2 million tons of almonds in 2019.[320] Much of U.S. production is for exports, which reached nearly $5 billion in 2019 (figure 2.10). The United States accounted for nearly 80 percent of total global almond production on average during 2015–20 and over 65 percent of global almond

[315] Academic professional, telephone interview by USITC staff, July 7, 2020; Dahllof and Horel, "Pesticide Chlorpyrifos Banned by EU," *EU Observer,* December 9, 2019; CalEPA, "Agreement Reached to End Sale of Chlorpyrifos," October 9, 2019; Hooker, "Chlorpyrifos Workshops Reach beyond One Pesticide," January 22, 2020.
[316] CDFA, "California Agricultural Production Statistics" (accessed September 24, 2020).
[317] CDFA, "California Agricultural Production Statistics" (accessed December 2, 2020).
[318] Based on 2017 Census data. USDA, NASS, QuickStats (accessed August 12, 2020).
[319] Includes HTS lines 0802.11, 0802.12, 0802.51, 0802.52, 2008.19.4000, and 2008.19.3020. USITC/USDOC DataWeb (accessed July 10, 2020).
[320] USDA, NASS, Quick Stats (accessed August 6, 2020).

exports on average during 2014–18 (by weight).[321] The EU is by far the largest export market for U.S. almonds, totaling over $1.8 billion in 2019. The value of these exports was more than twice that of the next largest market, India.

Figure 2.10 U.S. exports of almonds to major markets, 2016–19 (million dollars)

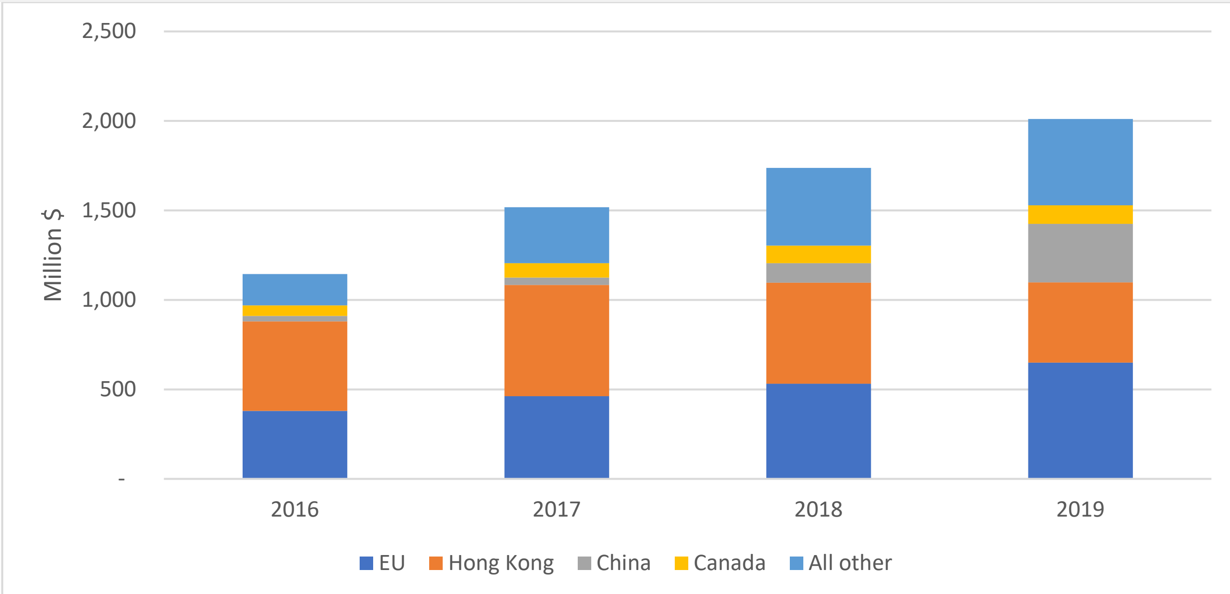


Source: Includes HTS lines 0802.11, 0802.12, and 2008.19.4000. USITC/USDOC DataWeb (accessed July 27, 2020).
Note on the EU data: The United Kingdom (UK) departed the EU in 2019. For purposes of this figure, the United Kingdom is included in the EU data throughout period. Corresponds to appendix table H.12.

The United States is also the world's largest producer of pistachios, producing 370,000 tons in 2019.[322] The United States supplied approximately half of average global pistachio production (by weight) during 2015–20 and nearly 40 percent of average global pistachio exports, by weight, in 2014–18.[323] The EU is the United States' largest export market by value for pistachios, accounting for about one-third of total exports. While China is the largest export market by volume, the unit price for the EU is higher, and it is considered the most important export market for U.S. pistachios (figure 2.11).[324]

[321] INC, *Nuts and Dried Fruits: Statistical Yearbook 2019/2020*," 14–15 (accessed July 10, 2020).
[322] USDA, NASS, Quick Stats, 2019 NASS survey, utilized, in-shell production, measured in dollars (accessed October 8, 2020).
[323] INC, *Nuts and Dried Fruits: Statistical Yearbook 2019/2020*, 42–43 (accessed July 10, 2020).
[324] Klein, "California Pistachio Industry Update," January 22, 2020.

Figure 2.11 U.S. exports of pistachios to major markets, 2016–19 (million dollars)



Source: Includes exports under HTS lines 0802.51, 0802.52, and 2008.19.3020. USITC/USDOC DataWeb (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Corresponds to appendix table H.13.

Pest Pressures and IPM Program

The U.S. almond and pistachio industries face several pest and disease pressures that can have significant impacts on production in terms of both quality and yield. Navel orangeworm is one of the most important pests: not only does it cause significant crop damage, but it also contributes to the spread of aflatoxin, a fungal toxin dangerous to human health. For most growers, insecticides are a necessary component of the IPM programs that the industry has developed to control navel orangeworm. These nut industries are increasingly concerned that the MRLs for key insecticides could be lowered. In particular, the EU has recently limited the use in the EU of one of the few active ingredients effective against navel orangeworm, methoxyfenozide. If the MRLs for methoxyfenozide for almonds and pistachios are lowered and these industries cannot secure an import tolerance, they report that significant disruption to their IPM systems would result, with negative impacts on both U.S. production and exports.

Pest pressure from navel orangeworm impacts domestic almond and pistachio crops, reportedly causing over $800 million in combined costs and damages to these industries each year.[325] The navel orangeworm has been a significant pest in California nut production since the 1960s.[326] Navel orangeworm damage occurs to crops when larvae hatch on the nuts and enter the nut to feed, damaging the nut and making it unmarketable. Navel orangeworm moths also carry spores of the fungi

325 APG, written submission to USITC, June 2, 2020, 2.
326 Zalom, "Arthropod IPM Opportunities," December 8, 2010, 25; Curtis, Klein, and Grant, "Painting the Landscape," April 10, 2019, 2; Kuenen and Siegel, "Protracted Emergence of Overwintering *Amyelois transitella*," August 1, 2020.

that produce the poisonous substance aflatoxin (discussed further below) and leave them on any nuts they touch.

The development of an extensive IPM program that includes use of insecticides has helped farmers mitigate the impacts of navel orangeworm damage and successfully limited the level of aflatoxin on nuts. Nonetheless, average annual navel orangeworm damage can reportedly reach up to 2 percent of the crop in both pistachios and almonds.[327] As navel orangeworm damage to nuts varies by year and location, there have been instances where even the most conscientious growers have experienced higher losses, leading to up to $1,700 of potential sales lost per acre of almonds.[328] Losses extend beyond the orchard, as insect-damaged nuts also increase processing costs. In 2018, Blue Diamond Growers reported an increase of $20 million in processing costs to meet the previous years' quality standards because processing speeds would need to be slowed in order to inspect and remove damaged nuts.[329] The pistachio industry calculates that the total annual costs of managing navel orangeworm for their industry exceeds $400 million.

Navel orangeworm is a significant pest to the tree nut industries not only because it causes damage to nuts, impacting the quality and quantity of nuts sold, but especially because the navel orangeworm moth is the most significant vector in the spread of the toxin aflatoxin.[330] Aflatoxin is a mycotoxin that is produced by two species of the fungus *Aspergillus* (*Aspergillus flavus* and *Aspergillus parasiticus*). Because aflatoxin can be deadly to humans and animals in high doses, many countries, including the United States, place maximum allowable levels for aflatoxin on food products to maintain food safety. Even a small amount of aflatoxin can lead to U.S. and international violations of maximum levels.[331]

As with pesticide maximum residue level violations, exceeding contaminant maximum levels can also have significant negative repercussions on exports and underscore the importance of controlling navel orangeworm. For example, the almond industry reported that pre-export sampling costs for aflatoxin are over $5 million annually, and in 2018 alone, the cost of rejected shipments was an additional $270,000.[332]

IPM programs combine research on the target pest and the environment with farmer's experiences to develop a program that combines the use of cultural practices, biologics, and pesticides. Neither cultural practices nor pesticides used alone can manage navel orangeworm, and even with best attempts at implementing these programs, farmers cannot completely eradicate this pest. Rather, IPM programs allow farmers to manage pests while minimizing costs and broader impacts. Recommended cultural practices to manage navel orangeworm include winter sanitation, mating disruption, the

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[327] Klein, "California Pistachio Industry Update," January 22, 2020; Klein, *Are Tree Nut Growers Doing Their Part?*, posted April 10, 2020; industry representative, interview by USITC staff, August 14, 2020.
[328] Higbee, "Navel Orangeworm Management," January 16, 2019; Caroom, "Evolving Pest: UC Addresses Navel Orangeworm's Growing Threat," May 17, 2018; Fitchette, "Almonds Enter Critical Period for NOW Control," June 27, 2018; Rominger, "Navel Orangeworm: A Costly Pest in Almonds," May 16, 2018.
[329] Caroom, "Almond Harvest May Reach 2.4 Billion Pounds," May 10, 2018.
[330] Navel orangeworms contribute to the spread of aflatoxin, and as the population increases in an orchard, not only does the percent of tested samples infected by aflatoxin increase, but the levels of aflatoxin present in these samples also increases. Michailides, *Successes and Challenges in Reducing Aflatoxin Contamination of Pistachios*, January 22, 2020; Picot et al., "Period of Susceptibility of Almonds to Aflatoxin," December 1, 2016.
[331] ABC, "Managing Navel Orangeworm during First, Second Flight," April 10, 2020.
[332] ABC, "Research Encourages More Aggressive Approach to Aflatoxin," June 28, 2019.

application of atoxigenic strains of *aspergillus*, the use of egg or pheromone traps, calculating degree days to monitor its spread, careful monitoring of hull splits, and early or timely harvests. In addition to these, farmers use insecticides that are specialized to target specific parts of the pest's lifecycle, along with some broad-spectrum pesticides**.**

One of these IPM practices, winter sanitation, is often considered the first line of defense against navel orangeworm.[333] The removal of "mummy nuts," nuts that remain on the tree after harvest, is reported to be one of the most effective means of controlling the population, capable of replacing one application of pesticide each season.[334] However, this task is labor intensive and expensive, and there are many barriers to carrying it out.[335] For example, labor and equipment may not be available when needed, or farmers may have difficulty accessing the orchard with the equipment needed in the winter because of soil conditions.[336] As a result, many farmers are not able to fully incorporate this form of navel orangeworm management.[337]

Research is beginning to identify additional cultural practices to help manage navel orangeworm, but their cost can discourage adoption. For example, mating disruption is a relatively recent and costly addition to navel orangeworm management, and is the result of 35 years of research on the pest.[338] Mating disruption uses hanging pheromone-emitting dispensers throughout the orchard which can disrupt mating for an entire season, reducing populations by up to 50 percent.[339] In spite of its effectiveness, only about half of pistachio and almond growers reportedly use mating disruption, likely as a result of high upfront costs.[340] Harvesting nuts early may also help prevent moth damage in almonds. After nearly a decade of research, growers discovered that this practice could significantly reduce the rate of navel orangeworm damage, and through it, aflatoxin rates and levels.[341] One potential barrier to this practice, however, is that nuts that are harvested early can be harder to process, which increases processing costs.[342]

Discovering, registering, and widely implementing alternatives that could reduce pesticide use takes years to become consistently effective and available to all farmers. As a result, alternatives to

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[333] Jeffries, "Combating Navel Orangeworm: Pyrethroid Considerations," April 8, 2015.
[334] Fitchette, "Almonds Enter Critical Period for NOW Control," June 27, 2018.
[335] Curtis, Klein, and Grant, "Painting the Landscape," April 10, 2019, 8; Nay, "UCCE Profile: Houston Wilson," August 6, 2020; Klein, "California Pistachio Industry Update," January 22, 2020; industry representative, interview by USITC staff, June 25, 2020.
[336] Nay, "UCCE Profile: Houston Wilson," August 6, 2020; Klein, *Are Tree Nut Growers Doing Their Part?*, April 10, 2020.
[337] Curtis, Klein, and Grant, "Painting the Landscape," April 10, 2019, 8; Nay, "UCCE Profile: Houston Wilson," August 6, 2020; Klein, "California Pistachio Industry Update," January 22, 2020; Klein, *Are Tree Nut Growers Doing Their Part?*, April 10, 2020; industry representative, interview by USITC staff, June 25, 2020.
[338] Curtis, Klein, and Grant, "Painting the Landscape," April 10, 2019, 11.
[339] ABC, "Managing Navel Orangeworm during First, Second Flight," April 10, 2020; Curtis, Klein, and Grant, "Painting the Landscape," April 10, 2019, 7, 11; Haviland, "Gill's Mealybug and Navel Orangeworm," January 22, 2020.
[340] ABC, "Managing Navel Orangeworm," April 10, 2020; Klein, *Are Tree Nut Growers Doing Their Part?*, April 10, 2020; Haviland, "Insect Management Update," January 16, 2019.
[341] Industry representative, interview by USITC staff, June 25, 2020; Klein, "California Pistachio Industry Update," January 22, 2020.
[342] Fitchette, "Almonds Enter Critical Period for NOW Control," June 27, 2018; Michailides, *Successes and Challenges in Reducing Aflatoxin Contamination of Pistachios*, January 22, 2020.

pesticides are limited. Over 10 years of research has led to another recent addition to navel orangeworm management: the release of nontoxic strains of *Aspergillus*, which can displace toxigenic strains at very low costs. However, supplies are limited, and the industry is still learning how to effectively use this crop protection tool.[343] And, while a better product has reportedly been identified, it has not yet been registered for use in tree nuts, but is hoped to be available for use by 2021.[344] Research is also in progress on another management method, the sterile insect technique for managing navel orangeworm.[345] The nut industry has allocated over $7 million in research thus far, and federal government funding of $6 million was appropriated to fund continuing research in 2020.[346]

Costs and Effects of Missing and Low MRLs

While IPM systems are effective, they can reportedly require millions of dollars in research and decades of work to develop, depending on the value and scale of production. They further involve substantial costs and time for farmers to implement. And, because navel orangeworm is just one of several pest pressures growers face, most growers are unable to incorporate all the recommended practices fully.[347] Industries report that developing IPM systems to manage navel orangeworm and ensure safe supplies of edible nuts is costly, can take decades, and cannot replace the use of pesticides. As a result, growers report that having to deal with low and missing MRLs may limit their ability to use the pesticides needed when pest pressures are high.

Insecticide use is an important part of the IPM program, though industry representatives report that neither the use of chemicals nor cultural controls alone can prevent navel orangeworm infestations.[348] Pesticide use is necessary to control navel orangeworm populations even if a farmer implements each of the cultural controls perfectly. Growers generally spray insecticides one to two times per season, though if there is a high population of navel orangeworm and a large share of late varieties planted, a third application may occur.[349] Each spray leads to a reduction of the pest by about 50 percent.[350]

While there are about a dozen active ingredients available for use against navel orangeworm (table 2.11), in practice growers' choices are more limited, as these products target different stages of the pest's life cycle. The pesticides available to farmers fall within three chemical classes of insecticides:

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[343] While costs of using AF36 are relatively low (it costs $5 per acre for pistachio on average), there have been issues with learning the best way and the best places to apply the treated seed to maximize effectiveness. ABC, "Research Encourages More Aggressive Approach to Aflatoxin," June 28, 2019; Michailides, *Successes and Challenges in Reducing Aflatoxin Contamination of Pistachios*, January 22, 2020.
[344] ABC, "AF36 Shows Promise in Fight against Aflatoxin," May 15, 2020.
[345] This technique involves sterilizing male NOWs and releasing them into the orchard to reduce the numbers of subsequent generations. ABC, "ABC Funds $1 Million in Navel Orangeworm," April 5, 2019; Wilson, *Update on Sterile Insect Program for Navel Orangeworm*, January 22, 2020.
[346] ABC, "ABC Funds $1 Million in Navel Orangeworm Research," April 5, 2019; Wilson, *Update on Sterile Insect Program for Navel Orangeworm*, January 22, 2020; Klein, *California Pistachio Industry Update*, January 22, 2020; APG, "$8 Million for Navel Orangeworm Sterile Insect Program," July 20, 2020.
[347] In the pistachio industry, it is estimated that one in eight growers implements all the recommended practices. Klein, *California Pistachio Industry Update*, January 22, 2020.
[348] Caroom, "Evolving Pest," May 17, 2018; UC IPM, "Navel Orangeworm: Almond" (accessed July 14, 2020).
[349] UC IPM, "Navel Orangeworm: Almond," accessed July 14, 2020.
[350] Curtis, Klein, and Grant, "Painting the Landscape," April 10, 2019, 12.

growth regulators (diacylhydrazines), ryanodine receptor agonists (diamides), and pyrethroids.[351] The main growth regulator used in almonds is methoxyfenozide, which targets navel orangeworm larvae, preventing them from molting.[352] Growth regulators and diamides are effective for three to four weeks and have less impact on beneficial pests than the pyrethroids and organophosphates.[353] Pyrethroids have limited utility because they are broad-spectrum and can harm beneficial pests that control damaging ones, and because they have become less effective at managing navel orangeworm.

To prevent pesticide resistance, growers need to rotate through the use of various pesticides with different modes of action. Growers are advised to not use the same mode of action (box 2.2) more than twice per season in treating crops for navel orangeworm.[354] Instead, pesticides with different modes of action must be alternated with each generation, so that the same mode of action is not used against two consecutive generations.[355] If they are not alternated, the pests will quickly develop resistance to that mode of action. Even with adequate rotations, certain modes of action will eventually become less effective. Pyrethroids have become less effective because they have been widely used over a long period of time.[356]

Box 2.2 Pesticides and Their Mode of Action

A pesticide works to control the targeted pest through a specific "mode of action." The mode of action is the way in which a pesticide disrupts specific biological processes in a pest.[a] While the mode of action groupings vary depending on the type of pesticide (herbicide, insecticide, or fungicide), all pesticides are categorized by their mode of action. Insecticides, for example, are grouped into five broad categories based on how the insecticide targets the pest (nerve and muscle, growth regulating, respiration, midgut, and unknown or nonspecific).

Each of these categories contains multiple modes of action, as there are a number of methods to disrupt these targeted areas in each pest. To illustrate, each of the different modes of action within the growth regulator grouping prevents insects from reaching later stages of development, but they do so by targeting different aspects of growth. There are also a number of pesticides that are effective using modes of action that are not yet known.[b] Finally, some modes of action can only be used at certain points in a pest's life cycle. An insecticide that inhibits growth of a juvenile pest will not be effective against adults. Awareness of a pesticide's exact mode of action is useful to prevent pest resistance, because repeated use of the same mode of action will lead to a pest becoming resistant to an ingredient more quickly than it would if that mode of action were cycled through with other modes of action.

[a] BASF, Insecticide Mode of Action¸ accessed October 22, 2020.
[b] IRAC, The IRAC Mode of Classification Online, accessed October 22, 2020.

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[351] Diamides also impact larva by preventing them from feeding. The main diamides used are flubendiamide and chlorantraniliprole. IRAC, IRAC Mode of Action Classification Online (accessed October 22, 2020); ABC, "Hullsplit Sprays" (accessed July 14, 2020).
[352] ABC, "Hullsplit Sprays" (accessed July 14, 2020).
[353] Niederholzer, "Navel Orangeworm Management at Harvest," May 29, 2015.
[354] The mode of action of an insecticide is the way in which it works on the targeted pest. For example, some modes of actions inhibit growth and are effective only during certain stages of the pest's lifecycle. While limiting consecutive uses of the same mode of action is consistent across crops, the number of times each mode of action should be used per season is determined by crop and pest pressure and may vary. IRAC, "Insecticide Mode of Action Tutorial," April 2019; UC IPM, "Navel Orangeworm: Almond" (accessed July 14, 2020).
[355] Niederholzer, "Navel Orangeworm Management Considerations," July 2, 2020.
[356] Industry representative, interview by USITC staff, August 14, 2020.

Only two of the available growth regulators for navel orangeworm are reported to provide effective, long-term control: methoxyfenozide and chlorantraniprole.[357] One other ingredient, cyantraniliprole, is also considered effective but uses the same mode of action as chlorantraniprole and cannot be used in conjunction with it. [358] As shown in table 2.11, farmers have at most four modes of action (grouped in the table by color), which is the way the insecticide works on the targeted pest. One of these—pyrethroids—has limited effectiveness.[359] Pyrethroids also harm beneficial insects, and because of low and missing MRLs in the EU, their use is limited. Two of the remaining modes of action are not effective in treating adult worms. These products are used every year in almond and pistachio orchards, and no additional pesticides that are known to manage navel orangeworm are in development.[360] As a result, where there are already concerns about potential resistance, there are now additional concerns about the potential to lose one important mode of action if the EU lowers MRLs.[361]

Table 2.11 MRLs for key active ingredients used in the almond and pistachio industries, grouped by mode of action, (parts per million)

Some values in cells are marked with footnote letter a, meaning that there is no MRL or import tolerance set by that market. Note: The mode of action of an insecticide is the way in which it works on the targeted pest. For example, some modes of actions inhibit growth and are effective only during certain stages of the pest's lifecycle. Mode of Action 28 are ryanodine receptor modulators, 18 are ecdysone receptor agonists, 5 are nicotinic acetylcholine receptor allosteric modulators, and 3A are pyrethroid sodium channel modulators. LOD = lowest limit of analytical determination. N.a. = not applicable.

Active ingredient	Mode of action	Stage/type	Codex MRL	U.S. MRL	EU MRL	Notes
Chlorantraniliprole	28	Larva	0.02 (almond) 0.3 (pistachio)	0.02 (almonds) 0.2 (pistachio)	0.05	EU registration expires 2024
Flubendiamide	28	Larva	0.1	0.06	0.1	EU registration expires 2024
Methoxyfenozide	18	Larva	0.1	0.1	0.1	EU registration expires 2026
Tebufenozide	18	Larva	0.05	0.1 (almond) 0.1 (pistachio)	0.05 (almond) 0.01 (LOD) (pistachio)	EU registration expires 2024
Spinetoram (spinosyns)	5	Larva; adult	0.01	0.1	0.05 (LOD)	EU registration expires 2024
Spinosad (spinosyns)	5	Larva; adults	0.07	0.1	0.07	EU registration expires 2021
Bifenthrin	3A	Pyrethroid, all life stages	0.05	0.05	0.05	Not-approved in the EU
Cyfluthrin	3A	Pyrethroid, all life stages	n.a.[a]	0.01	0.02 (LOD)	Not-approved in the EU
Esfenvalerate	3A	Pyrethroid, all life stages	n.a.[a]	0.2 (almond) (pistachio)[a]	0.05 (LOD)	EU registration expires in 2022
Fenpropathrin	3A	Pyrethroid, all life stages	0.15	0.1	0.01 (LOD)	Not approved in the EU

[357] Niederholzer, "Navel Orangeworm Management Considerations," July 2, 2020.; Haviland, *Insect Management Update*, January 16, 2019; industry representative, interview by USITC staff, August 14, 2020.
[358] Niederholzer, "Navel Orangeworm Management Considerations," July 2, 2020; Haviland, *Insect Management Update*¸ January 16, 2019.
[359] *Bacillus thuringiensis*, a biopesticide not shown in Table 2.11, is another product available to growers but also has limited effectiveness.
[360] Haviland, *Insect Management Update*, January 16, 2019; Caroom, "Evolving Pest," May 17, 2018; Niederholzer, "Navel Orangeworm Management Considerations," July 2, 2020.
[361] Industry representative, interview by USITC staff, July 25, 2020.

Active ingredient	Mode of action	Stage/type	Codex MRL	U.S. MRL	EU MRL	Notes
Gamma-Cyhalothrin	3A	Pyrethroid, all life stages	0.01	0.05	0.01 (LOD)	EU registration expires in 2025
Lambda-Cyhalothrin	3A	Pyrethroid, all life stages	0.01	0.05	0.01 (LOD)	EU registration expires in 2023
Permethrin	3A	Pyrethroid, all life stages	0.1	0.05	0.05 (LOD)	Not approved in the EU

Source: UC IPM, "Navel Orangeworm: Pistachio" (accessed July 2, 2020); UC IPM, "Navel Orangeworm: Almond" (accessed July 14, 2020); industry representatives, interviews by USITC staff, August 12, 2020; Bryant Christie Global, Pesticide MRLs database (accessed October 22, 2020). IRAC, "Insecticide Mode of Action Tutorial," April 2019. Insecticide Resistance Action Committee, "The IRAC Mode of Action Classification Online" (accessed January 19, 2021).

The EU has already limited the approval of one important tool in managing navel orangeworm, raising concerns about a potential change in its MRL. In 2019, methoxyfenozide was renewed in the EU, but only for greenhouse uses, due to potential groundwater impacts.[362] According to industry sources and EU practice, because it is a concern pertaining to the environment and not to human health, the MRL should remain at its current level for now, and it would normally act as an import tolerance if the approval is not renewed in 2026.[363] However, the European Parliament recently rejected an import tolerance for clothianidin because of the pesticide's impact on pollinators on a global scale. While import tolerances generally do not take environmental impacts in the growing market into consideration, the European Parliament's rejection of this import tolerance did so while noting its position that "effects on pollinators and the environment should be taken into account when evaluating MRLs."[364]

There is concern that if this is indicative of the EU's approach, this could lead to the loss of one of the only two modes of action that is available and effective against navel orangeworm.[365] Because nuts are sorted by size and quality, it is reportedly not possible to segregate orchards by destination market, so growers would have to grow to the lowest MRL or risk losing one of their largest export markets.[366] Even if it were possible to successfully secure an import tolerance, that process takes a few years and generally would not be initiated unless an MRL was lowered, or was not expected to be renewed.[367] The short transition periods when MRLs are lowered are also particularly problematic for products with long shelf lives, like nuts, potentially impacting products that are will spend over a year in

[362] European Commission, DG SANTE, *Final Renewal Report for the Active Substance Methoxyfenozide*, December 13, 2018.
[363] 2020 MRL Harmonization Workshop, "EU Concerns for Registrants," May 27, 2020; industry representative, interview by USITC staff, June 25, 2020.
[364] European Parliament, "Motion for a Resolution on the draft Commission regulation amending Annexes II, III and IV to Regulation (EC) No 396/2005," February 21, 2019; industry representative, interview by USITC staff, November 26, 2019; industry representative, interview by USITC staff, January 8, 2020; foreign government representative, interview by USITC staff, January 8, 2020; industry representative, interview by USITC staff, February 13, 2020.
[365] Industry representative, interview by USITC staff, June 25, 2020.
[366] APG, written submission to USITC, June 2, 2020, 3; ABC, written submission to USITC, December 13, 2019, 2; industry representative, interview by USITC staff, June 25, 2020; industry representative, interview by USITC staff, June 30, 2020.
[367] 2020 MRL Harmonization Workshop, "Coordination on EU MRL Topics," May 27, 2020.

the channels of trade, or the time spent between harvest and final end use. This could lead to an inability to sell those products or an increase in risks of an MRL violation.[368]

In addition, the registrations for many of the other key insecticides used for navel orangeworm control will expire in less than five years if they are not renewed. Industry representatives have voiced concern that as the IPM programs to manage navel orangeworm require the use of pesticides and there are no options in the development pipeline, if any of the current pesticides used were to lose MRLs or import tolerances, U.S. growers could face the loss of key export markets or yields, or face higher rates of rejections due to aflatoxin contamination.[369]

Hops

The U.S. hop industry, as one of only two major global producers, is highly dependent on exports and has invested considerable time and money to develop IPM systems to address threats to U.S. hop production from multiple pests and disease, including powdery mildew. However, since its IPM system depends on the availability of certain pesticides to function properly, the U.S. hop industry is increasingly concerned about the negative impacts that missing and low MRLs may have on their future production and profitability. Despite significant efforts by the U.S. industry to harmonize MRLs across markets, the EU has recently rejected the renewal of an important fungicide used against powdery mildew. The industry is apprehensive that the MRL for the relevant active ingredient may be lowered and that, if so, it may not be able to secure an import tolerance for this fungicide, an outcome that could undermine U.S. production and exports. As noted in volume one, the slow pace of approval in other export markets is also of concern.[370]

Industry Overview

In 2019, the United States was the world's largest producer of hops, accounting for approximately 40 percent of total global production. Germany is the only other major producer of commercial hops, producing slightly less than the United States.[371] In 2019, the U.S. hops industry farmed nearly 60,000 acres and produced a record 113 million pounds of hops, with nearly all coming from the three main producing states—Washington, Oregon, and Idaho.[372] While farmers in the region cultivate approximately 60 different hop varieties, 15 of those varieties make up most (80 percent) of total production.[373] Small farms, particularly those that grow specialty varieties, are not uncommon in the industry.

The hop plant, *Humulus lupulus*, is a perennial, climbing plant, and hops are the plant's seed cones. Hops are an important ingredient in beer, and there are several varieties used by brewers to create signature

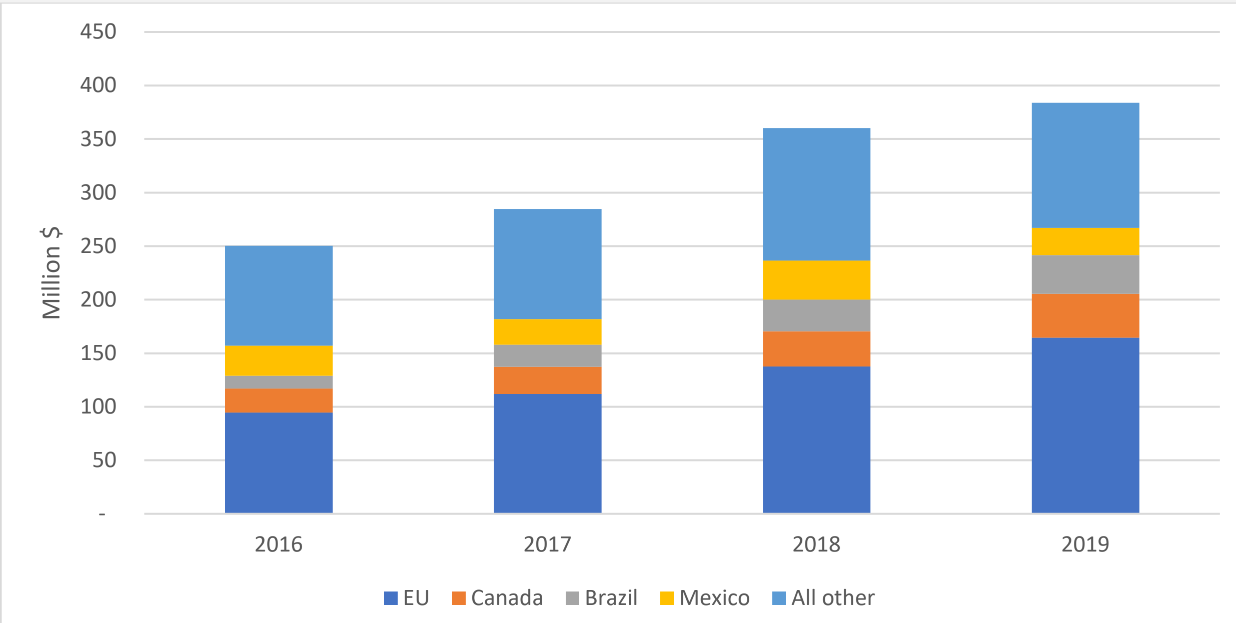
[368] ABC, written submission to USITC, July 31, 2020, 1–2; APG, written submission to USITC, June 2, 2020, 1; ABC, written submission to USITC, December 13, 2019, 3; industry representative, interview by USITC staff, June 25, 2020; industry representative, interview by USITC staff, May 14, 2020.
[369] Industry representative, interview by USITC staff, June 25, 2020.
[370] Industry representative, interview by USITC staff, July 9, 2020; industry representative, interview by USITC staff, August 14, 2020.
[371] International Hop Growers Convention, "Economic Commission—Summary Reports," February 2020, 2.
[372] Hop Growers of America, "2019 Statistical Report," January 2020, 3.
[373] Industry representative, interview by USITC staff, July 9, 2020.

flavors and aromas.[374] Brewers select specific hop flavor profiles needed to formulate specific beers. Accordingly, replacing a hop variety in a product once formulated is not possible without extensive experimentation and change in formulation, because the flavor and aroma of varieties differ significantly.[375]

Trade

The U.S. hop industry is highly export dependent, as more than 60 percent of U.S. hop production is exported to global beer producers.[376] The EU is the largest export market for U.S. hops by far, accounting for about 40 percent of U.S. hop exports in recent years (figure 2.12). Canada, the next largest export market, accounted for about 10 percent of U.S. hop exports in 2019.

Figure 2.12 U.S. exports of hops and hop extract to major markets, 2016–19 (million dollars)



Source: USITC/USDOC DataWeb (accessed July 27, 2020). Includes data for 1210.10, 1210.20, and 1302.13.
Note on the EU data: the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, the United Kingdom is included in the EU data throughout the period. Corresponds to appendix table H.14.

Pest Pressures and IPM Program

The U.S. hop industry faces several pest and disease pressures that can have significant impacts on production in terms of both quality and yield, and it reports that it has spent more than $6 million over

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[374] Galinato and Tozer, "2015 Estimated Cost of Establishing and Producing Hops in the Pacific Northwest," November 2016, 2.
[375] Hop growers generally contract with merchants, with whom they typically have five-year contracts. Galinato and Tozer, "2015 Estimated Cost of Establishing and Producing Hops," November 2016; industry representative, interview by USITC staff, July 9, 2020; industry representative, interview by USITC staff, August 14, 2020; industry representative, interview by USITC staff, August 14, 2020.
[376] USHIPPC, written submission to USITC, June 4, 2020, 2; USHIPPC, written submission to USITC, December 10, 2019, 3.

the past 27 years addressing regulatory MRL issues globally.[377] Hops are a specialty crop and, as a result, growers are said to have limited pesticide tools available for use and few in the development cycle. Hop growers must rotate products to minimize the risk of resistance, and they face constantly changing pressures, as demonstrated by their experience with powdery mildew, a fungus that can quickly change and adapt. While the degree of pest and disease pressure varies by the production region and hop variety, generally growers must monitor and treat four major pressures: powdery mildew, downy mildew, spider mites, and aphids.[378]

Powdery mildew is one of the most important pressures facing hop farmers; it also demonstrates the complexity of the pressures facing the industry. Powdery mildew, which is caused by *Podosphaera macularis,* has been impacting hop production globally for at least a century but had not reached the Pacific Northwest until 1997, when it was found in the Yakima Valley in Washington State.[379] Controlling the fungus is difficult because spores can travel for miles, and efforts to contain it have not been successful.[380] Powdery mildew can cause significant crop damage, including yield reductions of 20 percent or more. In some cases, it can lead to a complete loss of marketable crop.[381] Different hop varieties have differing levels of susceptibility to powdery mildew, depending on which strains are present in a particular location and also on the local climate. The fungus can develop new strains to overcome the resistance shown by some hop varieties and is reportedly one of the highest-risk organisms for developing resistance to fungicides.[382] However, fungicides are a key component of IPM programs, and the U.S. hop industry is increasingly concerned that the MRL for a key fungicide for powdery mildew, quinoxyfen, could be lowered in export markets. In particular, the EU has recently rejected the proposed renewal of this fungicide. If that MRL is lowered and the industry cannot secure an import tolerance for it, the U.S. industry is concerned about significant disruptions in U.S. exports of hops. Further, the slow pace of the approval of new active ingredients in other export markets is also of concern to the industry.[383]

Hops growers have already lost the ability to use some important pesticides in managing spider mites because of low and missing MRLs in export markets, and have faced issues with pest resistance as a result of the loss of a variety of modes of action.[384] However, the recent loss of approval of quinoxyfen used to manage powdery mildew in the EU has raised industry concerns about the potential disruption the loss of this MRL could cause to the IPM program.

[377] USHIPPC, written submission to USITC, June 4, 2020, 2.
[378] Industry representative, interview by USITC staff, July 9, 2020.
[379] Turechek et al., "Development of Management Strategies for Hop Powdery Mildew," January 2001, 8; Ocamb et al., "First Report of Hop Powdery Mildew in the Pacific Northwest," November 1999.
[380] Gent et al., "Managing Powdery Mildew in Hop," October 2019; Turechek, Mahaffee, and Ocamb, "Development of Management Strategies for Hop Powdery Mildew in the Pacific Northwest," January 2001.
[381] Gent et al., "Managing Powdery Mildew in Hop," October 2019; Sally D. O'Neal et al., "Field Guide for Integrated Pest Management in Hops," 25, 27 (accessed July 27, 2020).
[382] Gent et al., "Managing Powdery Mildew in Hop," October 2019; industry representative, interview by USITC staff, August 14, 2020.
[383] Industry representative, interview by USITC staff, July 9, 2020; industry representative, interview by USITC staff, August 14, 2020.
[384] Industry representative, interview by USITC staff, August 14, 2020. Growers effectively lose modes of action through the loss of pesticide approvals and their associated MRLs.

A number of cultural controls that help manage the mildew in conjunction with fungicide use have been identified. These include early spring sanitation measures, planting mildew-resistant varieties, using clean planting stock, removing infected buds and shoots, controlling growth on the lower parts of plants, checking for infection regularly, and avoiding excess application of nitrogen.[385] Harvesting hops earlier than was previously done is another cultural control method of reducing risk of infection. However, some of these methods may lower yields or quality, which can push down prices.[386] While these cultural controls are an important component of managing powdery mildew, they are often costly, not always possible to implement fully, and not sufficient to control the disease without fungicide.[387]

Pre-planting practices are important to contain the spread of powdery mildew but significantly increase costs. One important step in powdery mildew management is ensuring that plants produced in a nursery or greenhouse are not infected before planting.[388] In the past, growers might cut rhizomes from existing plants and plant those for new growth. However, because the rhizomes might already be infected, that practice risks greater spread of powdery mildew and can hamper its management. Implementing this aspect of the IPM program can help reduce the need to use pesticides later but can be a costly early investment. For example, while it is becoming more common now for growers to purchase potted plants from nurseries and greenhouses, this increases the costs of planting an acre from approximately $600 per acre to as high as $2,000 per acre.[389]

As powdery mildew can overcome even the strongest types of resistant hop varieties, growers rely on access to fungicides to control the disease. The Cascade cultivar, for example, has been grown in the Pacific Northwest for approximately 15 years and was previously resistant to powdery mildew. Recently, however, a strain of powdery mildew has been found on it that has overcome this resistance.[390] As a result, applications of fungicide on Cascade have increased from less than one application per year, on average, to between three and five applications, depending on location.[391] While the U.S. hop industry reportedly spends hundreds of thousands of dollars each year on breeding programs to develop resistant varieties, even resistant varieties require the use of some pesticide applications because applying low levels of fungicide appears to help the plants remain resistant for a longer period of time.[392]

Research has shown that spring pruning is an important means to manage powdery mildew and reduce pesticide costs. However, it is not always possible to implement this tactic fully. The fungus overwinters on the plants on the underground crown buds. In spring, when shoots emerge, if there are

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[385] Ocamb and Gent, "Hop (*Humulus lupulus*)—Powdery Mildew" (accessed July 27, 2020); Gent et al., "Association of Spring Pruning Practices with Severity," September 2012; Sirrine, "Pruning Hops for Disease Management and Yield Benefits," May 1, 2018.
[386] Ocamb and Gent, "Hop (*Humulus lupulus*)—Powdery Mildew" (accessed July 27, 2020); industry representative, interview by USITC staff, August 14, 2020.
[387] Industry representative, interview by USITC staff, August 14, 2020.
[388] Gent et al., "Managing Powdery Mildew in Hop," October 2019.
[389] Industry representative, interview by USITC staff, August 14, 2020.
[390] Powdery mildew can also overcome resistance, in part because the fungus can develop new strains relatively quickly. Gent et al., "Adaptation to Partial Resistance to Powdery Mildew," June 2017; O'Neal et al., "Field Guide for Integrated Pest Management in Hops," 2015, 28; Gent et al., "Managing Powdery Mildew in Hop," October 2019.
[391] Gent et al., "Adaptation to Partial Resistance to Powdery Mildew," June 2017.
[392] Industry representative, interview by USITC staff, August 14, 2020.

infected shoots, they will release spores into the air and infect other parts of the plants, including new leaves.[393] Spring pruning is an important means of removing these infected shoots, reportedly delaying the spread of powdery mildew by up to 4–6 weeks, which could allow growers to eliminate one application of fungicide per year.[394] However, it is often not possible to prune without chemicals. For example, certain types of irrigation systems may prevent farmers from pruning mechanically, which is more effective than chemical pruning. [395] However, the alternative type of irrigation system can reportedly harm the beneficial pests that can help control spider mites, another important threat to hops, and also has higher associated labor costs.[396]

Other cultural practices have helped manage the fungus, but can have unintended negative consequences, in addition to raising production and labor costs. Leaves at the base of plants can increase the spread of infection, so removing this basal foliage is particularly effective in reducing the severity of powdery mildew on cones.[397] Additionally, controlling weeds and managing cover crops increases airflow and reduces humidity. [398] However, while effective for powdery mildew management, each of these practices remove the habitat of beneficial pests that are natural predators of spider mites.

Costs and Effects of Missing and Low MRLs

While fungicides are a crucial part of the IPM systems used to control powdery mildew, hop growers have a limited number of registered active ingredients available for use against powdery mildew. There are approximately one dozen active ingredients currently available to growers in treating powdery mildew. (These are shown in table 2.13, grouped by mode of action, which is the process by which a fungicide works.) However, hop growers' pesticide use is further constrained by the fact that they can only use products that are also registered in all of the major export markets. Further, not only are some of the alternatives to pesticides available to growers more expensive and less effective, but they can also increase other pest pressures, leading to an overall increase in pesticide use. For example, sulfur can be used to treat powdery mildew, but using it can double the severity of spider mite outbreaks.[399]

In addition, growers must rotate modes of action to prevent resistance.[400] It is estimated that, in order to minimize resistance, at least four modes of action are needed to manage powdery mildew. Particularly high-pressure years or the use of susceptible hop varieties, however, may require up to six different modes of action. Table 2.13 indicates that there are currently eight modes of action that are at least somewhat effective against powdery mildew available to farmers in the United States. However,

[393] O'Neal et al., "Field Guide for Integrated Pest Management in Hops," 2015, 26.
[394] Gent et al., "Managing Powdery Mildew in Hop," October 2019; Sirrine, "Pruning Hops for Disease Management and Yield Benefits," May 1, 2018; industry representative, interview by USITC staff, July 7, 2020.
[395] Even mechanical pruning, however, cannot be used in certain years of the plant's development. Industry representative, interview by USITC staff, August 14, 2020; industry representative, interview by USITC staff, August 14, 2020.
[396] Industry representative, interview by USITC staff, August 14, 2020.
[397] Gent et al., "Managing Powdery Mildew in Hop," October 2019.
[398] Gent et al., "Managing Powdery Mildew in Hop," October 2019.
[399] Gent et al., "Effects of Powdery Mildew Fungicide Programs," February 2009; industry representative, interview by USITC staff, August 14, 2020.
[400] Mode of action refers to the specific cellular process inhibited by a particular fungicide. Some active ingredients may have modes of action that are not yet known. FRAC, "How Does Fungicide Resistance Evolve?" (accessed October 7, 2020); O'Neal et al., "Field Guide for Integrated Pest Management in Hops," 2015, 9.

three of those modes of action are not available because the associated active substances have not yet been approved in Japan and the EU. Without a sufficient number of modes of action, industry representatives report that growers will have to repeat use of certain modes, increasing the rate at which resistance will develop.[401]

Table 2.12 MRLs for key active ingredients used in the hop industry, grouped by mode of action (parts per million)

Some values in cells are marked with footnote letter a, meaning that there is no MRL or import tolerance set by that market. Cells marked with footnote letter b indicate the active substance is registered in the EU but is not approved for use on hop plants.

Note: Mode of action refers to the specific cellular process inhibited by a particular fungicide. Some active ingredients may have modes of action that are not yet known. Note: The numbers listed in the second column of this table identify a mode of action that applies to the fungicide listed in the first column. Modes of action are further grouped according to the way they act. MOA 50 is group B, cytoskeleton and motor protein; MOAs 7, 11, and 39 are group C (respiration); MOA 13 is group E (signal transduction); MOA 3 is group G (sterol biosynthesis in membranes); and any mode of action that begins with a U (such as U6 and U13, below) represents unknown modes of action. LOD = lowest limit of analytical determination. N.a. = not applicable.

Active substance	Mode of action	Codex MRL	Japan MRL	U.S. MRL	EU MRL	Notes
Fenarimol	3	5.0	5.0	n.a.[a]	5.0	Not approved in the EU.
Flutriafol	3	n.a.[a]	n.a.[a]	20.0	20.0	Not approved for hops in Japan, EU. EU registration expires 5/2024.
Myclobutanil	3	5.0	10.0	10.0	5.0	EU registration expires 5/2021.
Tebuconazole	3	40.0	40.0	35.0	40.0	EU registration expires 8/2020.
Triflumizole	3	30.0	8.0	50.0	0.1 (LOD)	Not approved in the EU.
Fluopyram	7	50.0	60.0	60.0	50.0	EU registration expires 1/2024.
Boscalid	7	60.0	60.0	35.0	80.0	EU registration expires 7/2021.
Pyraclostrobin	11	15.0	15.0	23.0	15.0	EU registration expires 1/21.
Trifloxystrobin	11	40.0	40.0	11.0	40.0	EU registration expires 7/2033.
Quinoxyfen	13	1.0	1.0	3.0	2.0	Substance was not reapproved by the EU in April 2019.
Metrafenone	50	7.00	70.0	70.0	80.0	EU registration expires 4/2021.

[401] Industry representative, interview by USITC staff, August 14, 2020.

Active substance	Mode of action	Codex MRL	Japan MRL	U.S. MRL	EU MRL	Notes
Fenazaquin	39	30.0	n.a.[a]	30	0.01 (LOD)	Not yet approved for hops in EU, Japan. EU registration expires 5/2023.[b]
Cyflufenamid	U6	n.a.[a]	n.a.[a]	5	0.05 (LOD)	Not approved for hops in the EU, Japan. EU registration expires 3/2023.[b]
Flutianil	U13	n.a.[a]	n.a.[a]	2	0.05 (LOD)	Not registered for use with hops in the EU, Japan. EU registration expires 4/2029.[b]

Source: Compiled by USITC, using FRAC Code List 2020, 2020. Bryant Christie Global, Pesticide MRLs database for active ingredients shown (accessed June 20, 2020). Insecticide Resistance Action Committee, "The IRAC Mode of Action Classification Online" (accessed January 19, 2021).

There are a number of fungicides that are effective against powdery mildew on leaves when the fungicides are applied preventatively. However, there are fewer effective options to act against it on cones.[402] While it is difficult to control the spread of the fungus, it is particularly difficult to manage infections of powdery mildew in hop cones. Even where the damage appears minimal, hop cones can be infected to a degree that makes them unacceptable for sale.[403] Only two active ingredients have shown effectiveness in protecting hop cones, and one, quinoxyfen, was recently non-renewed in the EU.[404] This also affects hop growers in Germany, the second-largest global producer. As a result, the IPM system in the EU has been disrupted, and farmers there report that they have had to return to practices of regular spraying based on number of days rather than monitoring for pest pressures, which results in increased use of alternative fungicides and hastens the growth of resistance.[405]

While this has already impacted EU growers, the U.S. industry risks losing the quinoxyfen MRL if the EU lowers the MRL and does not approve an import tolerance, as in the case of clothianidin.[406] If the use of quinoxyfen were to be lost, leaving only one active ingredient that is effective against hop cone infections, the industry reports that that growers would need to increase the use of alternative active ingredients. This increase could reportedly negatively impact the environment and also allow the fungus to become resistant to active ingredients quickly. This could lead to catastrophic yield losses, as seen in other regions in the past, that would impact global beer production.[407]

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[402] O'Neal et al., "Field Guide for Integrated Pest Management in Hops," 2015, 28.
[403] Gent et al., "A Decade of Hop Powdery Mildew in the Pacific Northwest," January 2008, 33.
[404] The only other product that is considered to be effective in protecting cones is a mixture of fluopyram and trifloxystrobin. O'Neal et al., "Field Guide for Integrated Pest Management in Hops," 28; European Commission, DG SANTE, "Final Renewal Report for the Active Substance Quinoxyfen," October 24, 2018; industry representative, interview by USITC staff, August 14, 2020.
[405] Industry representative, interview by USITC staff, July 22, 2020.
[406] See MRL Vol. 1 for more information on the European Parliament rejection of an import tolerance for clothianidin. Industry representative, interview by USITC staff, July 9, 2020.
[407] Industry representative, interview by USITC staff, August 14, 2020.

Hop growers cannot segregate crops by markets. As a result, because of the importance of export markets to the U.S. hop industry, U.S. hop growers often will grow to the lowest MRL. Because so much of hop production is exported, non-U.S. MRLs (and import tolerances) are as important to much of the domestic hop industry as domestic tolerances are. Hop growers report that it is difficult or impossible to grow to multiple standards. This is particularly problematic for producers of the niche varieties that fill an important role in the spectrum of flavor profiles sought by brewers, but which are often grown on smaller plots of land.[408] The U.S. hop industry reports that not being able to access the full range of pesticides approved for hops in the United States, as a result of missing or low MRLs in Europe and Japan, costs the industry approximately $50 million annually.[409]

Further, because of the long shelf life of hop pellets and extract, merchants and farmers must be wary of upcoming MRL changes as well. This can have negative effects not only on U.S. brewers but also on non-U.S. customers. For example, if the EU lowered the MRL on quinoxyfen, the short periods of time the EU typically allows for transitioning to a new MRL would have a greater impact on products with longer shelf lives, like hops, which can remain in the channels of trade for up to five years. This could keep brewers in Europe from importing U.S. hops that were grown using the product.[410] In one reported instance, a shipment of hops had arrived in the EU but had not been removed from a bonded warehouse before the transition period on an MRL change ended. The industry avoided a violation because of their extensive tracking and coding program, which allowed them to separate out the lots that could violate the new MRL and find new markets for that product. The industry reports that these successful efforts came at a cost of about $30 million.[411] If MRLs were removed for some of the key pesticides that hop growers need, it is possible that industry purchasing and contracting practices would have to change: industry would have to rely on contracting in advance for product specified for the EU, and certain varieties with lower resistance to the fungus would be unavailable to EU consumers.[412]

[408] Industry representative, interview by USITC staff, July 9, 2020.
[409] USHIPPC, written submission to USITC, June 4, 2020, 3.
[410] USHIPPC, written submission to USITC, June 4, 2020, 4; USHIPPC, written submission to USITC, December 10, 2019, 5; industry representative, interview by USITC staff, July 9, 2020; industry representative, interview by USITC staff, May 14, 2020.
[411] USHIPPC, written submission to USITC, June 4, 2020, 4.
[412] Industry representative, interview by USITC staff, July 9, 2020.

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Chapter 3
Economic Effects of MRLs

This chapter is the first of two chapters quantifying the economic effects of MRLs. This chapter examines these effects from a global perspective. It presents a picture of global MRLs and how they compare across markets (countries or customs unions with harmonized MRLs like the EU); estimates the relationships between MRLs and trade costs between markets; and quantifies the effects of MRLs on bilateral trade, prices, total imports, and total exports in a number of markets in different regions of the world. This analysis provides an indication of the effects of MRLs in a highly connected world in which the MRL policies in one market impact the rest of the world through the adjustment of trade flows and prices globally. By comparison, chapter 4 examines the effects of MRLs on a more local level, focusing on specific crops and on individual farms. In doing so, it provides an indication of the potential effects of MRLs on market participants who may not be able to individually adjust as readily as the broader markets described in this chapter.

Summary of the Global Economic Effects of MRLs

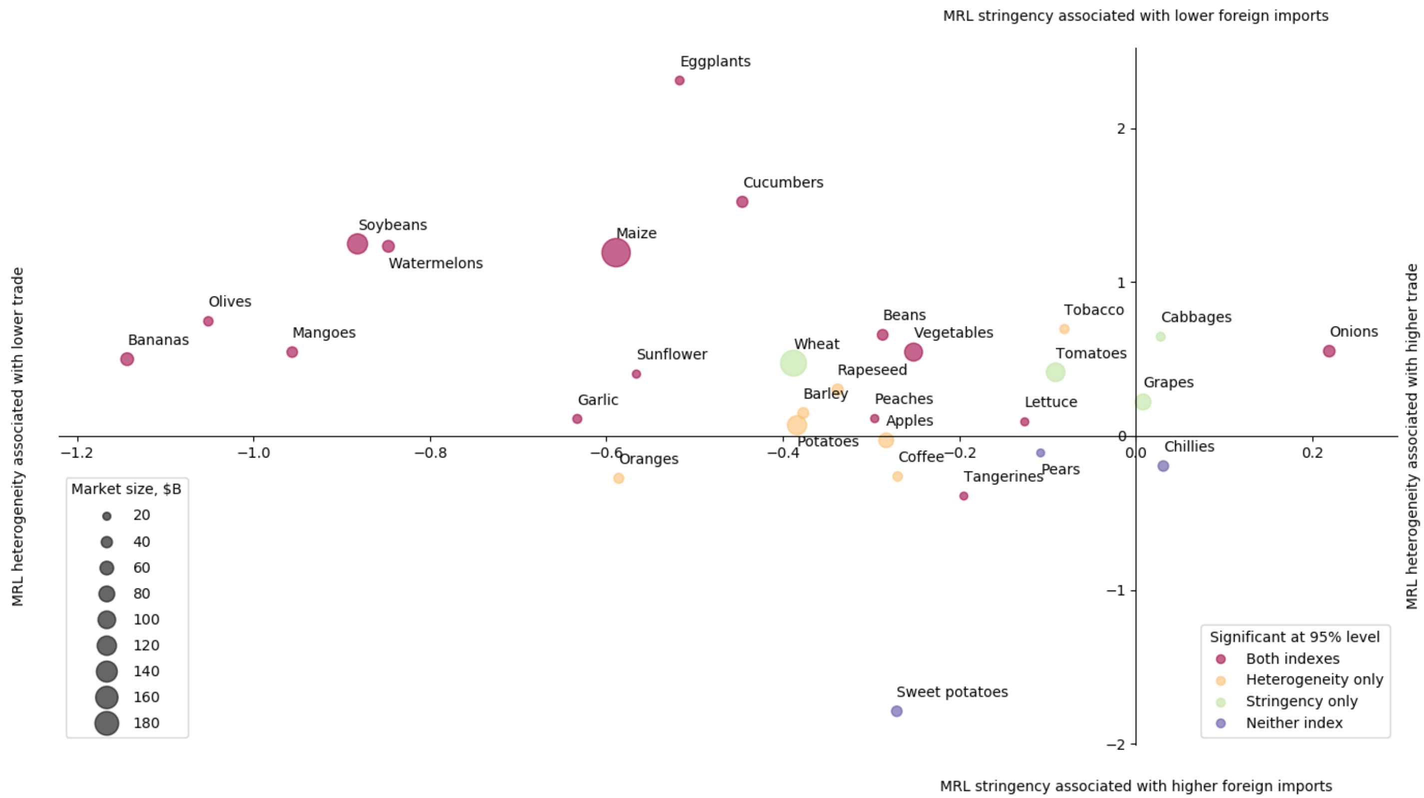
Globally, MRLs have affected bilateral trade in two ways: through the difference in MRLs between importing and exporting markets, and through the stringency of MRLs in the importing market. In the first case, difference in MRLs is often referred to as MRL heterogeneity, which is a term that will be used in this way throughout this chapter. In the second case, the stringency of the MRLs in an importing market may have its own impact, regardless of the MRLs in the exporting market.

The Commission's analysis finds that global trade patterns have been significantly affected by both MRL heterogeneity and stringency. However, the magnitudes and even directions of these effects differ across crops. Figure 3.1 plots the estimated effects of MRLs on bilateral trade for the largest 30 crops by average annual value of foreign trade and domestic shipments.[413] The figure depicts the relative impacts of both MRL heterogeneity (horizontal axis) and stringency (vertical axis) with each point on the figure corresponding to an individual crop, as noted by the labels.[414]

Most crops appear on the left side of the horizontal axis, where negative values indicate that MRL heterogeneity (divergence) deters bilateral trade. These crops include grains and oilseeds as well as a variety of fresh fruits and vegetables. Most of these crops experience a negative impact from MRL heterogeneity, with bananas, olives, and mangos experiencing the strongest negative impacts. Of the handful of crops where positive values indicate that MRL heterogeneity (divergence) is associated with higher trade, only one crop—onions—exhibits a statistically significant positive relationship.

[413] This analysis was conducted for 101 crop groups. The results for the remaining 71 crops are omitted here for brevity but are presented fully in appendix F.
[414] The values of these estimates are discussed more fully in a later section within this chapter.

Figure 3.1 Estimated effects of MRL heterogeneity and stringency, estimate values



Source: USITC estimates. The figure plots the estimated impacts of MRL heterogeneity and stringency on bilateral trade for the 30 largest crops by average annual value of trade and domestic shipments. A full table of estimates can be found in appendix F. The plotted values are the econometric estimates for each crop and index.
Note: Corresponds to appendix tables F.5, F.6, and F.7.

The vertical axis, which depicts the effects of MRL stringency in importing markets, demonstrates similarly varied impacts. A majority of the 30 largest crops appear on the positive portion of the vertical axis, where stricter MRLs are associated with lower foreign imports, suggesting that low MRLs act primarily as a barrier to trade. As noted above, the crops above the axis include grains and oilseeds (e.g., soybeans, maize, wheat, barley) along with a variety of specialty crops (e.g., eggplant, cucumbers, watermelons, beans, vegetables). Of these crops, eggplants, cucumbers (and gherkins), and soybeans exhibit the strongest negative relationship with MRL stringency. Only a handful of crops appear below the axis, where stricter MRLs are associated with higher foreign imports. Some citrus fruits such as tangerines (and mandarins, clementines, and satsumas) have had a positive relationship with importer MRL stringency, implying that on average, markets with stricter MRLs tend to import relatively more of these fruits. Finally, there are many products for which there has been no significant relationship between trade and MRL heterogeneity or stringency (or both). This model suggests that, for example, trade in sweet potatoes, pears, and chilies does not appear to be systematically affected by either MRL stringency or MRL heterogeneity (divergence).

The Commission used the estimated effects of MRL heterogeneity and stringency on bilateral trade to examine the global effects of a change in MRLs on prices and total imports and exports in different markets. As a case in point, a hypothetical scenario in which the European Union (EU) was to reduce its MRLs by 90 percent was simulated for three broad crop groups: tropical fruit, temperate fruit, and beans and peas.

The simulation model focuses on the effects of changes in MRLs in the EU because, as noted throughout volumes 1 and 2, Commission research uncovered numerous reports from a diverse, global perspective, highlighting the costs of complying with EU MRLs in particular. These compliance challenges are related to the high number of nonrenewals and reductions in EU MRLs relative to other major agricultural export markets. The EU is also a large and often a leading agricultural export destination for many suppliers worldwide. The simulated reduction in EU MRLs of 90 percent is reflective of actual past reductions to EU MRLs related to the evaluation of active substance renewals. Table 3.1 shows the reduction of existing EU MRLs for key pesticides used by a variety of agricultural sectors (see foreign producer case studies in chapter 5 of volume 1 and U.S. case studies in chapter 2 of this report). As shown in this table, the reduction of EU MRLs in recent years for key products used in agricultural production frequently is greater than 90 percent, particularly when MRLs are reduced to the default level of 0.01 percent.

Table 3.1 Selected active ingredients, by pesticide type and crop, for which EU MRLs have been lowered, reduction in parts per million (ppm) and percentage

Active ingredient	Pesticide type	Crop	Prior MRL (ppm)	Year amended	Current MRL (ppm)	Percent reduction
Buprofezin	Insecticide	Grapes	1.0	2019	0.01	99.0
Carbaryl	Insecticide	Pears	0.05	2020	0.01	80.0
Chlorpyrifos	Insecticide	Apples	0.5	2020	0.01	98.0
Diphenylamine	Fungicide	Apples	5.0	2018	0.05	99.0
Glufosinate-ammonium	Herbicide	Corn	0.5	2017	0.1	80.0
Glyphosate	Herbicide	Lentils	10.0	2012	0.10	99.0
Thiabendazole	Fungicide	Mangoes	5.0	2017	0.01	99.8

Sources: USITC, *Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels*, vol. 1, June 2020, chapter 5, and this report, chapter 2.

The model results show that the reduction in EU MRLs would have potentially significant impacts on EU members and their closest trading partners. However, other markets would largely be able to mitigate the effects of the changes by shifting their trade away from the EU and towards other partners. Although these results examine only the hypothetical scenario with the EU, they are informative about the broader impacts that MRLs have within a globally connected market for agriculture.

Although the impacts for each market depend on the crop group, several notable patterns emerged. For tropical fruit, the estimated effects of MRL heterogeneity and stringency would offset one another so that increased bilateral trade costs would be mitigated by higher demand for foreign imports. While most EU member states do not produce tropical fruit, the ones that do would experience reductions in producer prices by up to 1.9 percent (the percentage decline for Germany). By comparison, Spain, which is a large producer of tropical fruits (specifically of citrus fruit), would experience an increase in producer prices of 1.7 percent. At the same time, in most cases, consumer prices for EU countries would decline, resulting in higher purchasing power for citizens throughout the EU.

For both temperate fruit and fresh and dried beans and peas, the estimated effects of increased MRL heterogeneity and stringency would deter trade. As a result, foreign imports into the European Union would become more costly, and EU trade would shift inward to domestic producers and other EU countries. Most EU countries would experience increases in producer prices of up to 3.7 percent for temperate fruit (Germany) and 4.3 percent for beans and peas (United Kingdom[415]). For both crops, the increase in consumer prices would outpace growth in producer prices, resulting in lower purchasing power for EU citizens in most countries.

The impacts on non-EU markets would generally be less severe, primarily due to most markets' ability to shift some of their trade to alternative partners.[416] The United States, for example, would experience its largest price change—a 0.2 percent decline in producer prices—for temperate fruit. The non-EU markets most affected would be those with close ties to the European Union in the form of similar MRL policies and extensive established trade. For instance, Turkey, which is close to the European Union on both points, would experience relatively large impacts for all three crop groups—the largest being a 2.2 percent reduction in producer prices for tropical fruit.

The changes in MRLs and prices would also result in some large changes in total import and export values throughout the world. Depending on the change in MRL heterogeneity between particular markets and the changes in the stringency of different importers, total exports would change by up to 22.6 percent (the increase in Germany's export of tropical fruit) and total imports by up to 28.7 percent (the increase in Spain's imports of tropical fruit).[417] The decrease in EU MRLs also would tend to shift a

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[415] As discussed later in the chapter, the simulations are based on data from 2016. For this reason, the United Kingdom (UK) is treated as a member of the European Union (EU) with respect to the hypothetical scenario throughout. Additionally, at the time of writing, the UK retained EU MRLs for most products following its departure from the EU, including those analyzed here. Government of the UK, HSE, "EU Maximum Residue Levels (MRLs)—Basic Guidance."

[416] The apple and pears case study highlighted in chapter 2 of this report is illustrative of this trade diversion. As U.S. exports of apples and pears declined to the EU, apple and pear growers increasingly shifted exports to growing markets in East Asia. See chapter 2 of this report for further information.

[417] This reflects percentage changes; however, it does not take levels into account. Spain would have the largest percentage increase in imports but would not be the largest importer, nor would the change be the largest by value.

greater share of EU trade inwards, towards other EU countries and domestic markets, and away from other foreign partners.

These results demonstrate that the MRL policies set within markets can have a potentially significant global impact. For the markets with the closest ties to the European Union, the changes in prices could have real consequences on their citizens. For other markets that are able to mitigate the changes, the policies could still result in significant alterations in trading patterns.

Certain specific impacts of MRLs, such as yield effects, producer supply responses, or compliance risks, are captured by the empirical gravity model estimation and reflected in the simulation model results to the extent that they impact trade, but these are not independently addressed in this chapter. Chapter 4 addresses several of these effects more explicitly in the context of individual agricultural industries.

Analytical Approach to Gravity Modeling

This chapter includes quantitative analysis conducted using two models of international trade, both using a gravity framework. The first model is an empirical gravity model that uses trade data, production data, MRL data, and other standard gravity model inputs to evaluate the impact of MRLs on international trade at the crop level from 2006 to 2016. This model relies on the use of MRL indices and estimates the direct effects of changes to MRL stringency or heterogeneity. The MRL indices are calculated at the crop level and summarize pesticide restrictions and differences in these restrictions between markets.

The second model is a simulation gravity model. This model is an extension of the empirical model that takes into account both direct and indirect effects to evaluate the broader impact of changes to MRLs. The inputs to this model are similar to those of the empirical gravity model, but the simulation model has stricter data requirements and uses more aggregated crop groups. Alternative MRL indices are generated using hypothetical MRL changes and then used as inputs to this model to produce counterfactual prices and trade flows.

As noted, both gravity models use MRL data as an input. The Commission used MRL data from the Homologa database, which has MRLs for the specific pesticides applicable to individual crops for each market over time.[418] As there are too many pesticide/crop pairs to use directly in the estimation, this MRL data is used to construct MRL indices which summarize—at the crop level—the MRL stringency of a market or the MRL heterogeneity (difference) between two markets. Missing MRLs are accounted for by using market-level default rules.[419] The derived MRL indices are suitable for statistical estimation in the empirical model and can be recalculated using alternative MRLs (e.g., reducing a market's MRLs by some percentage) for use as inputs into the simulation model.

[418] Lexagri International, Homologa historical database (accessed February 6, 2020). The MRL data reflected in this report are sourced from the Homologa Historical Dataset from Lexagri. This time series panel of MRL data spanning from 2005 to 2016 for over 50 countries was used to develop the underlying foundation for the gravity model framework, the MRL indices. Data transformations and MRL index calculations are described in appendix E.
[419] The process of applying default rules is discussed in more detail in this chapter and in the technical appendix.

Organization of the Chapter

The remainder of chapter 3 is organized into three sections. The first section provides an overview of MRL data, a description of select MRL statistics for certain markets and crops, and a description of MRL trends. The next section describes the construction of the MRL indices, including how the modeling takes into account missing and low MRLs. The chapter concludes with a section detailing the gravity analysis and estimated global impact of MRLs.

MRL Data and Indices

This section first provides an overview of MRL data, focusing on a subset of data to illustrate important features and trends. The discussion involves MRLs associated with bananas, a tropical specialty crop described in a case study in volume 1, for a subset of markets. The discussion of MRL statistics uses banana MRLs as an illustration of the complexity of differing MRLs in markets worldwide. This section next describes how we use this MRL data to create MRL indices for use in the gravity models.

MRL Data and Comparisons

The MRL data in this report are sourced from the Homologa Historical Dataset from Lexagri. This dataset contains a time series panel of MRL data spanning from 2005 to 2016, for over 50 countries. The dataset contains the numerical MRL value for each crop/active substance pair that is present on a covered country's positive list.[420] Only countries that maintain positive lists available to Homologa are included in this dataset (though there are some countries that may not use positive lists). In addition to information on the positive list of each country covered, the dataset also contains information on current default rules for these countries. The dataset can be used to understand the stringency of a country's MRLs and the heterogeneity between MRLs from two different countries.

Missing MRLs matter. Many differences in MRLs come from the default rules that markets apply, including numerical default rules. Where MRLs are missing from a positive list, low default MRLs apply or, for markets without default policies, the model assumes no residue level is tolerable, implying an MRL of zero. The size of a market's positive list is another significant factor affecting this measure, since it can affect how often default rules are applied. Markets vary in how they create their positive lists and apply default rules. For example, in the EU the size of its positive list might be less important in terms of characterizing the stringency of its MRLs, as it explicitly creates a positive list entry for MRLs on active substances ("actives") used by its trading partners, even if that MRL is the default value (usually 0.01 ppm, but sometimes a specific limit of determination). That means that the EU has a large positive list with few MRLs classified as "missing," because many of its "established" MRLs are set at the default value—one reason its average established MRLs are lower than those of most markets. Some markets (particularly developing countries) may have very short positive lists but defer to Codex MRLs (or

[420] A positive list refers to a list of MRLs for specific crop/active substance pairings established by an importing country with which imports (and domestic producers) must comply. For crop/active substance pairs not on an importing country's positive list, the country may apply a default rule such as deferral to the Codex MRL or a low default value. Otherwise, the absence of an MRL on an importing country's positive list means that imports that are treated with the active substance are not allowed.

another market's MRLs), which increases the number of MRLs available for trade. While this practice is helpful, given the limited number of existing Codex MRLs, it still means that MRLs are more often "missing" in developing countries than they are in the EU.

As noted above, largely due to the nature of its positive list system, the EU's positive list included 1,049 MRLs for bananas in 2016, out of the total 1,167 MRLs for bananas represented across a subset of economically significant markets (table 3.2).[421] In comparison, Codex had established only 54 MRLs on bananas. Many developing countries rely on Codex, but the average established EU MRL on bananas is substantially lower (0.33 ppm) than the average Codex MRL (1.40 ppm).[422]

Table 3.2 Summary of MRLs for bananas in select markets (2016)
Superscript letter a notes 1,167 unique actives represented when combining the positive lists of active ingredients approved by these markets for bananas. Superscript letter b notes default MRL values are restricted to active substances registered for use with the stated crop by at least one market on the short list of select markets. Note: Codex does not have default rules and is not an actual market. However, there are markets that defer entirely to Codex, so a zero-tolerance default rule is applied here to cover those scenarios

Market	Number of established MRLs[a]	Mean established MRL	Mean default MRL[b]
Australia	109	3.11	0.00
Brazil	43	0.49	0.03
Canada	33	2.51	0.10
China	69	0.91	0.00
European Union	1,049	0.33	0.01
Japan	676	0.42	0.01
South Korea	463	0.34	0.01
Mexico	23	0.77	0.04
Morocco	7	0.03	0.07
United States	61	0.96	0.00
South Africa	29	10.61	0.00
Codex	54	1.40	0.00

Source: Lexagri International, Homologa Historical Dataset with aggregation and adjustment by USITC.

The MRL heterogeneity index, presented later in this chapter, provides a way of systematically comparing the stringency of markets' MRLs even when their positive lists are constructed in different ways. The heterogeneity index includes two important factors influencing the difference in MRLs between two markets. One is the amount of overlap between positive lists, and the other is the similarity in MRL values for actives that exist on both lists.[423] Having low overlap between lists or having significantly different values for MRLs on both lists contributes to higher (i.e., more divergent) MRL heterogeneity index values. Comparisons are displayed in tables 3.3 and 3.4 below. These tables highlight some of the challenges, discussed throughout this report, that growers face when exporting to markets where MRLs may be missing or low.

[421] The tables in this section report some key features of the MRL dataset. Bananas are used in these examples since tropical fruits are analyzed in several chapters of this report and since most countries are likely to have banana MRLs (compared to the likelihood of having green coffee MRLs, for example). MRLs from 2016 are used, since that is the most recent year used in the gravity model analysis.

[422]The term "established" MRL is used in this chapter to refer to an MRL on a positive list; a "default" MRLs is an MRL that is set through a default rule (by referencing another market's or a Codex MRL or by using a default numerical value) when an MRL is missing from a positive list.

[423] The overlap between positive lists is calculated using the number of MRLs in the intersection of the exporter's and importers' positive lists divided by the number of the MRLs on the exporter's positive list.

When a market with a large positive list (e.g., EU, Japan, or South Korea) imports a crop product, it will often have corresponding MRLs for most active ingredients on an exporter's positive list. On the other hand, when a market with a large positive list exports to a market with a short positive list, default rules are more likely to be applied. Table 3.3 illustrates how closely the positive lists of some agricultural trading partners overlap for banana MRLs. Higher percentages indicate that the importing market's positive list includes more of the actives from the exporting market's positive list. For example, Australia has 109 banana MRLs, of which the EU's positive list of 1,049 MRLs contains 97 percent. However, Canada's positive list of 33 MRLs has only 13 percent of the MRLs from Australia's positive list. Markets with similar list sizes can still have relatively little overlap. Mexico and South Africa (ZAF) respectively have 23 and 29 registered actives for bananas, but South Africa has only 26 percent of Mexico's approved actives, and Mexico has only 21 percent of South Africa's approved actives. The United States and Codex have 61 and 54 approved actives, respectively, and about 60 percent overlap from either direction.

Table 3.3 2016 MRLs for bananas: Percentage overlap of MRL lists by importer and exporter
Values are the number of MRLs existing on the intersection of the importer (column) and exporter (row) positive lists divided by the size of the exporter positive list, expressed as a percentage and rounded to an integer. Note: color coding is as follows: green (75–100 percent), light yellow (50–74 percent), orange (25–49 percent), and red (0–25 percent). A market's positive list overlap with itself is omitted and shaded grey. Any changes in the number of MRLs since 2016 are not reflected in this table.

Market (MRLs)	Australia	Brazil	Canada	China	EU	Japan	South Korea	Mexico	Morocco	USA	South Africa	Codex
MRLs in market	109	43	33	69	1,049	676	463	23	7	61	29	54
Australia	--	26%	13%	31%	97%	95%	93%	15%	4%	37%	14%	35%
Brazil	65%	--	30%	42%	100%	95%	86%	33%	5%	67%	19%	65%
Canada	42%	39%	--	30%	97%	85%	73%	15%	3%	67%	9%	55%
China	49%	26%	14%	--	94%	87%	84%	16%	3%	29%	12%	39%
EU	10%	4%	3%	6%	--	55%	40%	2%	1%	6%	2%	5%
Japan	15%	6%	4%	9%	85%	--	63%	3%	1%	8%	4%	8%
S. Korea	22%	8%	5%	13%	90%	93%	--	5%	1%	12%	5%	11%
Mexico	70%	61%	22%	48%	100%	100%	91%	--	9%	83%	26%	61%
Morocco	57%	29%	14%	29%	100%	86%	71%	29%	--	57%	43%	29%
USA	66%	48%	36%	33%	100%	93%	89%	31%	7%	--	11%	57%
S. Africa	52%	28%	10%	28%	86%	86%	79%	21%	10%	24%	--	34%
Codex	70%	52%	33%	50%	100%	98%	94%	26%	4%	65%	19%	--

Source: Lexagri International, Homologa Historical Dataset.

In addition to differences in the MRLs on positive lists across countries, comparisons of MRL values between positive lists for two sample markets show that there can also be significant variety in MRL values. Table 3.4 shows the average MRL ratios between markets and their partners for active substances that are registered on both positive lists. In this table, a value greater than 1 indicates that the importer has higher MRL values, on average, than the exporter. For example, when Canada is the exporter (row) and South Africa is the importer (column), the value is 1.55, indicating that South Africa has MRLs that are about 55 percent higher (i.e., less stringent) than Canada's MRLs when solely comparing the MRLs of active substances that are on the positive list for both countries.[424] A value lower

[424] The values only compare the markets' MRLs; they do not take into account what products a country imports or exports. The gravity model presented later in the chapter captures both effects.

than 1 indicates that the importer has lower (i.e., more stringent) MRL values on average than its exporting trade partner.

Table 3.4 illustrates the important difference in stringency between MRLs, including between Codex and the EU. As noted throughout the report, growers in many developing countries rely on Codex MRLs. However, in comparing Codex MRLs to those of the EU, the EU's MRLs are about 57 percent more stringent than those of Codex.[425] Similarly, when the United States exports to the EU, the United States faces MRLs that are, on average, 62 percent more strict than the United States' own MRLs when limiting the analysis to active substances on both markets' positive lists. The modeling in this chapter explores how important such divergent MRLs are for determining trade.

Table 3.4 2016 Bananas: Average MRL ratios for active substances on both positive lists, select markets
These averages are calculated from the ratio of the MRL of the importer (column) market over the MRL of exporter (row) market for each active that occurs on the positive list of both markets. Values across the main diagonal are reciprocals. Values are rounded. For example, when the United States exports to the EU, the United States faces MRLs that are, on average, 62 percent more strict than the United States' own MRLs when limiting the analysis to actives on both markets' positive lists. This value comes from the United States row and EU column, which indicates that EU MRL values for bananas are, on average, 38 percent of the United States' banana MRL value average when comparing actives that are on both countries' lists.

Market	Australia	Brazil	Canada	China	EU	Japan	South Korea	Mexico	Morocco	United States	South Africa	Codex
Australia	—	0.35	0.86	0.82	0.22	0.63	0.11	0.92	0.14	1.14	1.67	0.81
Brazil	2.84	—	1.12	1.27	0.67	1.74	0.16	1.48	0.35	2.08	2.01	1.68
Canada	1.16	0.89	—	2.05	0.60	1.24	0.22	1.26	1.00	1.05	**1.55**	1.16
China	1.22	0.79	0.49	—	0.27	1.05	0.23	0.96	1.58	1.20	1.48	0.90
EU	4.63	1.49	1.66	3.65	—	1.61	0.70	3.44	1.58	2.64	7.50	2.31
Japan	1.59	0.57	0.81	0.96	0.62	—	0.38	1.31	0.71	1.53	2.61	0.86
South Korea	9.11	6.09	4.57	4.41	1.43	2.65	—	6.36	0.66	9.44	13.41	6.83
Mexico	1.09	0.68	0.80	1.04	0.29	0.77	0.16	—	0.04	1.21	0.61	1.11
Morocco	7.07	2.83	1.00	0.63	0.63	1.41	1.52	24.49	—	5.89	1.71	1.00
United States	0.88	0.48	0.95	0.83	0.38	0.66	0.11	0.82	0.17	—	1.18	0.97
South Africa	0.60	0.50	0.64	0.68	0.13	0.38	0.07	1.65	0.58	0.85	—	1.03
Codex	1.24	0.59	0.86	1.12	0.43	1.16	0.15	0.90	1.00	1.03	0.97	—

Source: Lexagri International, Homologa Historical Dataset, with aggregation and adjustment by USITC staff.

Creating Indices to Measure MRL Policies

The complex nature of MRL policies required that a simplifying approach be taken to incorporate MRL information into the gravity framework. This report uses information about MRL levels and differences over time as key inputs to the quantitative models. Following the extensive past work in the economic

[425] For example, when Codex MRLs are taken as the exporting market MRLs (row) and the EU is the importer (column), the average EU-over-Codex ratio is 0.43.

literature,[426] these historical MRLs were used to generate indices of MRLs—numerical values better suited to statistical modeling than the raw MRL data.

Existing historical MRL data were aggregated into two types of MRL indices. The first type of MRL index calculated for this report is a heterogeneity index. This index is calculated for every possible exporter-importer pair in the Homologa sample for a given year, with higher numbers indicating that the importer is stricter than the exporter. Constructing the index involves taking the difference between the exporter MRL and the importer MRL for each active ingredient assigned an MRL by the exporter for a specific crop. When the exporter MRL is lower (i.e., more stringent) than the importer MRL, the difference is bounded at zero.[427] The differences are scaled by the global average MRL for the given crop and active ingredient, and the index is the average of these values. More information about this process can be found in the technical appendix (appendix E).

The second type of MRL index used in this report is a stringency index. This is a unilateral measure, calculated for each market at the crop level. While some research uses a stringency index with a form similar to that of the heterogeneity index, including both in the same statistical analysis can cause estimation issues due to multicollinearity.[428] The stringency index in this report avoids that issue by using a substantially different form from the heterogeneity index. The calculation is done in two steps. The first step identifies the most commonly approved active ingredients each year for each crop group. The second step takes the non-weighted, non-scaled average MRL for these active ingredients for each market, using default rules as necessary. The stringency index is higher for markets with less restrictive MRLs on common active ingredients.

Approach on Missing and Low MRLs

Missing and low MRLs are addressed in the construction of the indices. In the indices, low MRLs are not specifically identified as such in a binary fashion; instead they are treated as relative values compared to those of other markets. High values of the heterogeneity index indicate that the importer has much lower (stricter) MRLs than the exporter, while low values indicate that either the markets have similar MRLs or that the importer has higher (less restrictive) MRLs than the exporter. The stringency index is a direct average of MRLs for a subset of active ingredients/substances that are applied most frequently for a crop across all markets in the sample, so higher values in this measure should be interpreted as indicating less stringent policies.

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[426] See, for example, Winchester et al., “The Impact of Regulatory Heterogeneity,” 2012; Li and Beghin, “Protection Indices,” 2014; Xiong and Beghin, “Disentangling Demand-effects,” 2014; Shingal and Ehrich, “Trade Effects of Standards Harmonization,” 2019; and Hejazi, Grant, and Peterson, “Hidden Trade Costs?” 2016. Additionally, see chapter 6 of volume 1 of the report.

[427] This approach is similar to that used in Burnquist et al., “Heterogeneity Index of Trade and Actual Heterogeneity Index,” 2011, 24.

[428] In econometrics, multicollinearity refers to cases in which two or more variables are closely (or perfectly) related and reflect the same information. Multicollinearity poses a problem because it becomes impossible to accurately estimate the effects of these variables because they overlap. Since the heterogeneity index is an arithmetic average of differences in country MRLs scaled by the world average MRL, a stringency index using an arithmetic average of country MRLs scaled by the world average MRL would be a highly linearly related variable. The model would potentially struggle to distinguish between the effect of heterogeneity and the effect of stringency, and small changes to the data could cause unreasonably large changes to the estimated coefficients on these variables.

Missing MRLs are also not identified in a binary fashion. In the case of missing MRLs, both types of indices use applied MRLs. This entails filling in missing MRL values using a market's stated default rules. Since the heterogeneity index uses the set of exporter MRLs to determine the active ingredients considered, in this index, default MRLs are applied only for the importer. In the stringency index, default MRLs are applied if a market does not have an established MRL for one of the globally common active substances. Default rules are available at the market level (i.e., are not crop-specific) and consist of an ordered sequence of alternate MRLs to apply in the case of a missing MRL. For example, a market may first apply a Codex MRL, but in the absence of a Codex MRL, will next use the United States MRL to fill in a "missing" MRL for the crop and active ingredient in question. All sequences end with a numerical default value—some markets have only a numerical default value that gets applied in all cases. If a market does not state a numerical value, including cases where a market does not have any stated default rules, the index uses 0.0 (zero tolerance) as the numerical default value.

The default rules applied in this analysis are important in identifying low MRLs. An importer with relatively high MRLs but with a low number of approved active ingredients (and thus a low number of established MRLs) and a strict default rule could produce a heterogeneity index that is as high as or higher or a stringency index that is as low as or lower than an importer with moderate or low MRLs but with a more comprehensive set of approved active ingredients (and thus a more comprehensive set of established MRLs).

Although default rules are available from the current Homologa database, default MRLs are not available in the MRL time series data. For this reason, current default rules are used to define past years for the construction of the index, implicitly assuming that each market is fairly consistent in how it treats missing MRLs. Markets that do not have a positive list, and instead apply (or reportedly apply) default rules, are not included in the Homologa database, MRL indices, or the subsequent empirical or simulation gravity models. This limits the direct analysis that can be done for developing countries that do not maintain a positive list, as many of these countries defer to Codex. Additional national- and farm-level analyses presented in chapter 4 capture some of the likely effects on one such developing country (Costa Rica) by taking into account gravity model outputs from markets with positive lists close to Codex and also by incorporating information from market-specific case studies.

Limitations of the MRL Data and Indices

Constructing the MRL indices involves some assumptions and tradeoffs. Many of these limitations stem from the necessity of aggregation—MRLs are set at a granular level that is not conducive to direct statistical consideration within the context of international trade, which occurs on a product level. Aggregating all active ingredients approved by an exporter at the crop level removes the ability to analyze the impact of restrictions on specific active ingredients in order to produce a single number that can be used in the empirical model. However, as discussed elsewhere in volume 1 and in the case study chapter of this volume, specific active ingredients can be particularly important to farmers and can also be more efficient than alternative pesticides.[429]

The indices constructed in this report have another layer of aggregation for crops. Homologa provides MRLs at a very detailed crop level, but not all markets use the same level of detail. Therefore, the Homologa crop names were mapped to the crop names of the Food and Agriculture Organization of the United Nations (FAO) to reconcile different naming conventions between markets. Active ingredients were similarly aggregated. More detail about how these identifiers were aggregated is given in the technical appendix (appendix E).

There are two elements of the MRL heterogeneity index structure that involve important tradeoffs. The first element is how differences are calculated. The index structure used in this report uses linear differences, so a 10 percent difference between the exporter and importer MRLs relative to the global average changes the heterogeneity index by exactly twice as much as a 5 percent difference. Although some research has used an exponential difference, such that a 10 percent difference would have more than double the effect on the index compared to a 5 percent difference, this report uses the more commonly adopted linear approach.

The other element of the index structure is that both indices use a simple average. The heterogeneity index uses a simple average across all active ingredients approved by the exporter. That means that the heterogeneity index assigns all active ingredients the same weight and does not take into account that some are more important to agricultural production than others. (The particular importance of certain active ingredients in reducing pest pressure on specific U.S. crops is discussed in greater detail in chapter 2.) On the other hand, the stringency index takes a simple average across a limited number of common active ingredients and is therefore less impacted by the use of a simple average, allowing the combination of the two measures to give a balanced approach.

There are also a few data limitations involved in constructing the index. As noted above, many important markets, particularly some major developing countries which are discussed in detail elsewhere in this report, are not included in the data, since they do not maintain their own positive list of MRLs. Another limitation is the difference between established MRLs (as reported in the Homologa data set) and enforced MRLs —it is possible that some markets do not fully monitor or enforce their MRLs. Since data on that potential gap do not exist at the level of detail required for systematic analysis, this report uses the established MRLs. This index also accepts MRLs as comparable, regardless of any market-specific differences in residue definitions.

Finally, missing MRLs are inherently hard to measure. This information is incorporated in the heterogeneity and stringency indices through the “applied MRL” approach, which uses established MRLs when available and otherwise uses default rules reported by Homologa to infer what MRLs would be applied by importing markets. In addition to the index structure considerations described above, missing and default values have the added difficulty that they are, by definition, not established. Markets take different approaches, including setting a numerical default, deferring to those of other markets or groups (such as Codex), or, in some cases, simply incorporating “defaults” into their positive list. The

[429] Certain studies have focused on specific pesticides and crops. See, for example, Wilson and Otsuki, “To Spray or Not to Spray,” April 2004; Scheepers, Jooste, and Alemu, “Quantifying the Impact of Phytosanitary Standards,” June 2007; Chen, Yang, and Findlay, “Measuring the Effect of Food Safety Standards,” April 2008. However, this approach is not suitable when there are alternative pesticides which substantially mitigate the impact of MRL changes on the specific pesticides. The number and variety of crops and pesticides within the scope of this study necessitate a broader approach.

zero-tolerance assumption in the default rules may not always hold; however, even if a market is willing to unofficially accept a higher MRL, the uncertainty would still be expected to be a barrier for the exporter. No alternative index specifications or missing MRL assumptions were identified that could reflect this limitation.

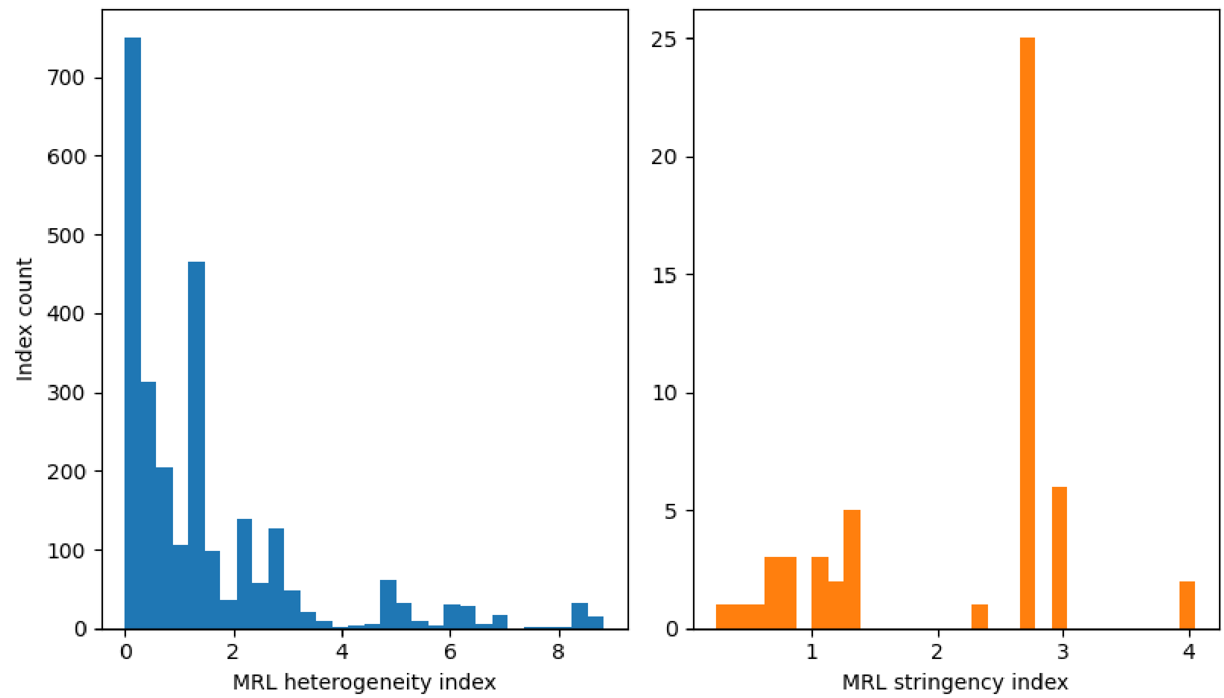
Further complicating the use of defaults is the uncertainty about how markets test and enforce default MRLs. The applied MRL approach offers a systematic way to measure and compare a large number of markets, crops, and active ingredients, but some specific combinations of these things will produce counterintuitive results. One scenario in which the heterogeneity index is less informative is when an exporting market has many active ingredients on its positive list that are not actually used domestically, as the index will exaggerate the number of default rules that need to be applied by the importer. In particular, if the exporter is a market that codifies default rules into the positive list (e.g., the European Union), then the heterogeneity index will in many cases essentially compare default rules. Since many countries do not have stated numerical default rules that are then assumed to be zero tolerance in the absence of another applicable rule, this can lead to larger heterogeneity index values. The stringency index is not susceptible to this issue since it is restricted to the nine globally most common active ingredients.

Key Statistics of MRL Stringency and Heterogeneity

MRL heterogeneity and stringency indices show that there is wide variability in the levels of regulatory heterogeneity between markets. For example, figure 3.2 includes a depiction of the heterogeneity index and the stringency index for bananas. The histogram on the left shows that the heterogeneity indices range from 0, implying no stricter requirements in the importing market, to 8.83, which represents the greatest regulatory difference between two markets. Most indices in 2016 were between 0 and 2 with a median value of about 1, suggesting that potential trading partner pairs will face fairly low heterogeneity for banana MRLs, although this does not quantify the impact that differences in MRLs may have on trade.

To put the values in the figure 3.2 in context, consider the heterogeneity index values between United States as an importer and the markets from which it imports. The United States' smallest heterogeneity index values (0.53) are with Laos and Cambodia, implying that both countries' MRLs are generally close to the United States'. By comparison, the United States' median index value is about 1.30, which is approximately equal to its index with the European Union and is representative of the differences faced between a large share of markets. The United States' largest heterogeneity indices are with Indonesia (8.83) and Ukraine (6.77). To illustrate the relationship between the United States and major banana suppliers, its heterogeneity indices with Colombia and the Philippines are 0.79 and 1.47, respectively.

Figure 3.2 Heterogeneity index values between country pairs and stringency index values of various countries, bananas in 2016, as histograms



Source: USITC calculation based on data from the Lexagri International Homologa historical dataset. Index values are presented as histograms reflecting the count of index values in each interval.
Notes: Corresponds to appendix table H.15.
Higher values of the heterogeneity index indicate that the MRLs of two countries are more divergent. Higher values of the stringency index indicate that a country has higher (less restrictive) MRLs on common active substances for a crop.

The MRL stringency indices are variable, but the vast majority of countries are at the same level of stringency, as implied by the stringency index values close to zero. As an example, the MRL stringency index histogram (right) in figure 3.2 depicts the values for the importer stringency indices for bananas in 2016. The median value is 2.69, which is also the index value for the EU. The lowest stringency values, which reflect the most restrictive policies, are those of Canada (0.24), South Korea (0.48), and the United States (0.60). The highest indices are for New Zealand (4.05) and Australia (3.96).

The stringency index is low when a market applies low (more stringent) MRLs to active substances that are commonly reported for a particular crop. The applied MRL could be low because the market established a stringent MRL to the common active or because the active is not on the positive list for that crop, since default rules are often more restrictive than MRLs on the positive list. An example is Canada, which has a low (stringent) stringency index for bananas but relatively high exporter heterogeneous index values for bananas. These observations indicate that Canada is less stringent than other markets when restricting to MRLs on Canada's positive list for bananas, but that Canada has either strict MRLs or missing MRLs for the globally most commonly approved actives for bananas. Table 3.5 displays stringency index values for bananas in 2016 for select markets.

Table 3.5 2016 Bananas: Stringency index values for select markets

Market	Value
Australia	3.96
Morocco	2.93
Codex	2.93
European Union	2.69
Mexico	1.35
Brazil	1.26
Japan	1.03
China	0.81
South Africa	0.79
United States	0.60
South Korea	0.48
Canada	0.24

Source: USITC calculation based on data from the Lexagri International Homologa historical dataset.

Low heterogeneity index values can indicate one of two things: the exporter could be more stringent than the importer, or the exporter and importer could have similar MRLs. An example of the first case is seen with 2016 banana MRLs when considering the trading pair of the EU and Canada. When the EU is the exporter, the heterogeneity index is very low (0.16). However, when Canada is the exporter, then the heterogeneity index is much higher (2.51).[430] Together, this indicates that the EU generally has stricter MRLs on bananas than Canada. In contrast, the EU and Morocco have relatively similar MRLs, with pairwise values of 0.47 and 0.67, respectively. Part of the similarity between the EU and Morocco comes from their numerical default rule of 0.01 ppm (although Morocco defaults to Codex MRLs first when available). When the index is high for both directions in a pair, it means that the pair has very mismatched MRLs. For example, when Australia is the exporter and South Africa is the importer, the index is 5.16. When the trade direction is reversed, the value is still 4.86. Australia has stricter MRLs than South Africa when comparing actives on both lists, but South Africa has a smaller list and requires more default rules to be applied when treated as the importer.[431] Pairwise heterogenous index values for select markets can be found in table 3.6.

[430] This is an illustration and may not reflect a likely scenario (in this case, scenario being Canada as an exporter of bananas).

[431] These patterns can be seen in tables 3.3 and 3.4.

Table 3.6 2016 Bananas: Heterogeneity index values for select markets
Note: markets labelled on the vertical axis represent exporters, while markets labelled on the horizontal axis represent importers. Values will differ when a market is either an importer or exporter due to the relative differences between the banana MRLs of market exporters and importers.

Market	Australia	Brazil	Canada	China	European Union	Japan	South Korea	Morocco	Mexico	United States	South Africa	Codex
Australia	0	5.13	4.13	5.07	4.73	3.77	4.77	4.96	5.01	4.89	5.16	5.13
Brazil	1.60	0	0.97	1.68	1.40	1.37	1.61	1.51	1.48	1.49	1.72	1.63
Canada	3.45	3.37	0	3.47	2.51	2.46	3.21	3.09	3.36	1.99	3.68	3.36
China	2.87	3.02	2.18	0	2.65	2.00	2.61	2.74	3.02	3.06	3.26	3.02
European Union	1.29	1.32	0.16	1.31	0	0.38	0.48	0.47	1.32	1.30	1.34	1.32
Japan	2.87	3.06	1.67	3.00	2.19	0	2.15	2.33	3.02	3	3.07	3.06
S. Korea	1.27	1.34	0.63	1.31	0.70	0.42	0	0.74	1.33	1.34	1.36	1.36
Morocco	1.11	0.84	0	1.22	0.67	0.76	0.76	0	1.11	1.11	0.95	1.15
Mexico	2.08	2.28	1.92	2.51	2.32	1.43	2.14	2.45	0	1.44	2.35	2.52
United States	2.42	2.75	1.55	2.96	2.30	1.88	2.74	2.68	2.40	0	3.16	2.79
S. Africa	4.86	5.09	4.83	5.42	4.93	4.36	4.77	5.06	4.95	5.39	0	5.31
Codex	0.59	0.31	0.59	0.66	0.35	0.23	0.69	0	0.15	0.53	0.90	0

Source: USITC calculation based on data from the Lexagri International Homologa historical dataset.

Estimating the Global Effects of MRLs

A gravity model of trade was used to estimate the effects of MRLs on trade flows and simulate the likely impact of a change to MRLs in certain markets. This type of model is an ideal tool for conducting this analysis, as described in the literature review in chapter 6 of the first volume of this report.[432] The gravity model is especially well suited for analyzing nontariff trade determinants such as MRL policies because of its ability to directly estimate their effects on trade without requiring any specific assumptions about the nature or magnitude of those relationships.

The gravity framework models bilateral trade flows as being dependent on bilateral trade costs, the production and relative prices of the exporting market, and the expenditures and relative prices of the importing market. Within the model, markets with high demand or large production tend to trade extensively with similarly large markets. These trading relationships are further reinforced by forms of trade facilitation like trade agreements and are weakened by costs such as physical distance, linguistic and cultural differences, and policy barriers. By combining these many determinants of trade, the model is effective at explaining the bilateral trade between each pair of markets in the world. The model has gained much of its popularity due to its success as a theory-grounded econometric model that performs well using extensive public information about bilateral trade, market characteristics, trade policies, and types of trade costs.

To assess the impact of MRLs on agriculture trade, gravity models were used in two capacities. First, an empirical version of the model was used to econometrically estimate the relationship between MRLs and bilateral trade. This econometric analysis, which covered 101 individual crop groups, identified the extent to which each crop has historically responded to MRL policies, using real-world data on trade and

[432] See Head and Mayer, "Gravity Equations," 2014; Disdier and Head, "The Puzzling Persistence of the Distance Effect," 2008; and Yotov et al., "An Advanced Guide," 2016, for surveys of the gravity model and recent uses.

MRLs between 2006 and 2016. The model estimates resulting from the empirical gravity model highlight the direct effect that MRLs have had on the value of bilateral trade between trading partners.

In addition, the Commission used a simulation version of the gravity model to analyze the likely effects of changes in MRLs on trade and other economic indicators using the MRL estimates from the empirical model. The simulation version of the model introduced additional types of economic relationships that could not be analyzed in the empirical model.[433] These additional relationships capture a more complete set of effects, such as indirect third-party trade creation/diversion or income/wealth effects that may result from changes in MRL policies.[434] The simulation model examined a smaller sample of three broad crop groups—tropical fruit, temperate fruit, and fresh and dried beans and peas—and estimated the joint, compounding, and mitigating effects of different aspects of MRLs.

Together, the empirical model provides a direct analysis of the effects of MRLs on bilateral trade, while the simulation model gives a broader analysis of combined impacts of MRLs on trade and the global economy. Additional details about the gravity model can be found in appendix F.

Because of the extensive number of MRLs simultaneously present on most agricultural products and the complex nature of the policies, it is easiest to discuss their impacts in terms of a specific example. Throughout this chapter, both the empirical and the simulation gravity model results are interpreted in terms of a hypothetical reduction of EU MRLs by 90 percent.

The focus on this hypothetical reduction was motivated by several factors. The European Union is the largest agricultural import market in the world, and for many exporting markets, the EU market comprises the majority of their sales. The EU is also actively reviewing a large number of active substances and existing MRLs under its regulatory timelines to determine whether or not they will be renewed. The EU's MRL policies were also frequently cited by industry representatives, hearing witnesses, and case study participants as being a source of concern, particularly in regard to the nonrenewal of MRLs for active substances in key pesticides that were considered essential by farmers. The EU's default of 0.01 ppm, which is applied in such cases, is frequently a very substantial percentage change decrease from previously established MRLs. With these concerns in mind, the decision to reduce MRLs by 90 percent in these simulations was intended to approximate the effect of MRL removals for important active substances.

The analysis in this section builds upon the existing economic literature on MRLs, which is discussed extensively in chapter 6 of the first volume of this report. A majority of studies have concluded that more stringent MRLs or those that differ between exporter and importer pairs (i.e., are more heterogeneous) have trade-reducing effects. However, some studies have concluded that lower importer MRLs can have trade-increasing effects. Many studies have found that the size and direction of effects can vary across markets, with lower-income exporters more likely to reduce exports to

[433] Specifically, the expanded simulation version of the model is able to determine the relationships between trade costs and consumer and producer prices in each market. It is also able to examine the subsequent, compounding effects that changes in these prices have on global trade patterns.
[434] See Yotov et al., "An Advanced Guide," 2016, for a description of the simulation gravity model.

destinations with lower MRLs due to their relative inability to afford the additional costs necessary to meet more restrictive import requirements.[435]

Like much of the economic literature on the subject, the Commission's gravity analysis depicts a nuanced picture of MRLs. For most crops, MRLs have inhibited trade in two ways. First, lower (i.e., more stringent) MRLs in importing markets are associated with smaller import values from foreign exporters, implying that strict MRL policies have represented barriers to import. Second, differences in MRLs between trading partners also represent a barrier to trade, regardless of the absolute level in either market. However, these relationships are not present for all crops. For some crops, lower importer MRLs were associated with greater foreign imports. This finding is consistent with some literature that has suggested that MRLs are an important signal of quality to purchasers or consumers and may increase demand for all agricultural products meeting such standards.[436] They are also consistent with economic literature suggesting MRLs are more prominent on crops that are heavily imported because they may be used as policy tools in response to existing trade, either as legitimate measures to protect public health or as a form of protectionism.[437]

The simulation results of the broader effects of MRLs told a similarly nuanced story. While the details of these simulations are presented in a later section, the lowering of European Union MRLs would have the following general effects. First, the policy change would affect the ability of non-EU exporters to access the EU market. For tropical fruit (in particular citrus), the change in MRL stringency would be associated with an increase in the demand for EU imports from all sources, but the increase in MRL heterogeneity associated with lower EU MRLs would mitigate this effect for many. For temperate fruit and fresh and dried beans and peas, the trade costs of importing the crops from foreign sources in the European Union would increase because of the changes to both MRL heterogeneity and stringency. Second, the policy change would increase the EU's ability to export to most markets in all three sectors that were modeled, which would have a significant effect on EU countries that are large producers of any of the three crops.[438] Third, the effects of the policy change on non-EU markets would be much smaller in most

[435] Several studies that have previously presented findings with respect to the trade impacts of MRLs include Ferro, Otsuki, and Wilson, "The Effect of Product Standards on Agricultural Exports," January 2015; Xiong and Beghin, "Disentangling Demand-Enhancing and Trade-Cost Effects," July 2014; Drogué and DeMaria, "Pesticide Residues and Trade, the Apple of Discord," December 2012; Winchester et al., "The Impact of Regulatory Heterogeneity on Agri-Food Trade," August 2012; Hejazi, Grant, and Peterson, "Hidden Trade Costs?" June 2018.

[436] If consumers believe that the imposition or increasing stringency of an MRL improves the quality of a commodity or helps communicate positive information about the good, the MRL may increase overall demand for imports. This demand increase may in turn increase the good's import volumes even if the good's production and/or trade costs increase. See, for example, Xiong and Beghin, "Disentangling Demand-effects," 2014, and Shingal, Ehrich, and Foletti, "Re-estimating the Effects of Stricter Standards," 2017.

[437] This literature suggests that there is simultaneity bias: the pre-existing trade relationship informs the imposition of MRLs, rather than the other way around. For importers, MRLs will appear in markets where consumers already have a preference for regulation of pesticide residues, so trade flows being attributed to imposition of standards are actually due to unobserved consumer preferences. A similar understanding could motivate exporters' MRL regulations as well, if exporting markets are setting stricter MRLs for products that their producers most frequently export. Li, Xiong, and Beghin, "The Political Economy of Food Standard Determination," 2017, and Shingal, Ehrich, and Foletti, "Re-estimating the Effects of Stricter Standards," 2017.

[438] Within the model, the quantity of crops produced was fixed for each market so changes in exports reflect a combination of (1) diversion to or from domestic markets or other countries and (2) changes in prices, which affect the *value* of exports. The model assumes total production capacity is not limited by more stringent MRLs.

cases, due to either limited relationships with EU countries or the markets' ability to shift their trade to other unaffected partners. Taken together, the effects of the policy change would be significant for many EU countries and their closest trading partners.

Although useful, the gravity model is subject to some limitations. First, the MRL indices used in this analysis and throughout the economic literature necessarily compress a large amount of information on many pesticides into a single value for each crop and trading pair. As a result, many potentially impactful types of heterogeneity across different pesticides are lost. For example, these indices do not attempt to distinguish potential differences in the relative importance of different pesticides. For a full discussion of the limitations of the MRL data and indices, see "Limitations of the MRL Data and Indices" above.

Second, empirical analyses like the gravity models described in this chapter are effective at identifying the effects that MRLs have had on trade. However, they are themselves limited in their ability to determine the precise cause of those effects. For example, the empirical models cannot determine the extent to which a reduction in exports spurred by a change in MRLs was the result of higher trade costs, lower crop yields, or other potential factors.

Third, the gravity model is retrospective, meaning that it is only able to estimate the effects of MRLs based on past changes in MRLs. For this reason, it may not be well suited to estimating the likely impacts of new MRL policies that are substantially different from those that have historically been in place. For example, it may not be able to properly estimate or simulate cases in which MRLs become entirely prohibitive and farmers are unable to meet the requirements. Discussions of such scenarios are covered elsewhere in this report, including through quantitative analysis in chapter 4.

Fourth, the models were constrained by the availability of data. The data were primarily limited by the availability of MRL policy information throughout the world. The Homologa database permitted the analysis of up to 38 markets. However, while these markets included some developing countries, they were disproportionately developed countries and—in particular—European Union members. Thus, many other markets, especially smaller developing countries, were absent from the analysis.

Fifth, the simulation gravity model features fixed production, representing a short-term picture of the world in which prices can adjust to changes in MRLs but the quantity produced of each crop cannot. To compensate for this limitation, additional analysis was undertaken to describe the likely adjustments that farmers would make to their production process following MRL changes. This national and farm level analysis is described in chapter 4.

Estimating the Direct Effects of MRLs on Trade

An empirical gravity model of trade was used to estimate the direct effects of MRL heterogeneity and stringency, as discussed in the previous section. In addition to the two MRL indices, several other types of variables were included to control for other important determinants of trade. These controls included the physical distance between markets; the presence or absence of colonial ties, common languages, shared borders, or preferential trade agreements; and European Union membership.[439] The model also controlled for market-level factors such as income, market size, and preferences. Finally, domestic

[439] These data were source from the Dynamic Gravity dataset created by Gurevich and Herman, "The Dynamic Gravity Dataset," 2018.

shipments were included in the model. Because domestic shipments are not subject to many of the frictions faced by international trade, they represent a valuable comparison group that improves the estimation of international trade costs.[440]

The estimations used trade and production data from the Food and Agriculture Organization of the United Nations Statistical Division (FAOSTAT) for the even years from 2006 to 2016.[441] These data covered all markets for which the necessary MRL information was available from Homologa.[442] The gravity estimation was conducted using the USITC's Gravity Modeling Environment (GME) software package for each of 101 crop groups.[443] This generated crop-specific estimates of the direct impacts of MRLs for each crop.

The gravity estimates indicate that MRLs have a widely varying impact across crops. The results of the estimations for the 30 largest agriculture products by average annual trade value (foreign trade plus domestic shipments) are presented graphically in figure 3.1 as well as in in table 3.7.[444] The estimates can be interpreted in the following ways. For importer MRL stringency, a positive coefficient indicates that importers with stricter MRLs tended to import less from foreign sources. A negative estimate value indicates that importers with stricter MRLs tended to import more from foreign sources. For MRL heterogeneity, a negative estimate value indicates that greater heterogeneity in MRLs between trading partners was associated with lower bilateral trade. A positive estimate value indicates that greater heterogeneity in MRLs was associated with higher bilateral trade. In both cases, the magnitude of the estimate reflects the strength of the effect such that larger estimates indicate larger effects.

The estimates presented here highlight several general relationships between agriculture trade and MRLs. Looking at MRL stringency, imports of most crops were reduced by lower MRLs, indicating that MRL stringency has acted as a restriction on foreign imports. To demonstrate the magnitude of effects of MRL stringency, consider peaches and nectarines, which has an estimated effect (0.11) that is comparable to the median effect across all crops (0.13). For peaches and nectarines, a 1 unit increase in the stringency index—representing a relatively significant reduction in stringency—would increase

[440] Models that do not include domestic shipments inherently estimate the effects of international frictions relative to other international frictions, which may underestimate the true costs of international trade. Additionally, the inclusion of domestic trade costs allows for the estimation of heterogeneous domestic trade costs, which further improves the accuracy of the estimates. For further information on the role of domestic shipments in these trade models, see Yotov et al., "An Advanced Guide," 2016; Yotov, "A Simple Solution," 2012; Ramondo, Rodríguez-Clare, and Saborío-Rodríguez, "Trade, Domestic Frictions, and Scale Effects," 2016.
[441] FAO, FAOSTAT database (accessed October 29, 2019). Two-year intervals were primarily used to reduce the computational burden of estimating the wide number of sectors. However, some past literature has also argued that doing so mitigates concerns regarding the misestimation of certain components that take longer than one year to adjust to economic changes (see Cheng and Wall, "Controlling for Heterogeneity," 2005).
[442] Countries for which the information on applied MRLs was not complete enough due to positive lists or partial default lists could not be included.
[443] https://www.usitc.gov/data/gravity/gme.htm.
[444] A subselection of estimates are presented here for brevity. A complete collection of estimates covering all 101 crops is presented in appendix F.

bilateral trade by nearly 12 percent.[445] Among these crops, eggplants, cucumbers and gherkins, and soybeans exhibit the strongest negative impact from strict MRLs. However, this relationship is not universal. Most of the largest crops (21 out of 30) show negative trade impacts from more stringent MRLs, while 6 show no significant effect at the 90 percent level. For three crops (sweet potatoes; oranges; and tangerines, mandarins, clementines, and satsumas), stricter MRLs were associated with higher imports. Oranges, for example, would have experienced a 24 percent decrease in bilateral trade as the result of a 1-unit increase in the stringency index.

With regard to MRL heterogeneity, the results indicate that trade between markets has typically been reduced by divergent MRLs. The median estimated impact is −0.25, which is similar to the estimate for beans (−0.28). The impact of a 1-unit increase in the heterogeneity index, which represents a sufficiently large change to move most markets from a relatively low level of heterogeneity to a relatively high level, would decrease bilateral trade in that product by nearly 25 percent. Bananas, for example, would experience a 68 percent decrease in bilateral trade as a result of a 1-unit increase in heterogeneity.[446] The crops most affected by MRL heterogeneity were bananas; olives; and mangoes, mangosteens, and guavas. In total, most of the largest crops (23 out of 30) show negative trade impacts, 6 crops show no significant effect at the 90 percent level, and 1 shows a positive effect on trade from more heterogenous MRLs. For several crops, the model estimates indicated that MRL stringency and/or MRL heterogeneity have had no significant systematic impact on trade, suggesting that trade in these products is determined by factors other than MRLs in most cases. Pears and chilies and peppers show no relationship with either measure of MRLs. Other crops, such as apples and coffee, appear to be

[445] Figure 3.2 and its discussion provide a description of typical index values and give context for the relative size of a 1-unit increase in either index. The value of a 1-unit change is similar in both the heterogeneity and stringency indices, meaning the trade impacts of a 1-unit change in each index are roughly comparable. For the heterogeneity index, the mean value is 1.95, with a standard deviation of 2.74. The mean stringency index is 1.72, with a standard deviation of 3.84. This means both indexes are on roughly the same scale and that a 1-unit change represents a relatively similar change about 36 percent and 26 percent of a standard deviation for heterogeneity and stringency index, respectively.

[446] On average, there is evidence that an increase in the MRL heterogeneity index may deter trade to a greater extent than a comparable increase in the stringency index. It is difficult to directly compare the trade impact of heterogeneity and stringency because they measure different aspects of MRLs; heterogeneity measures bilateral policy divergence, while stringency measures unilateral MRL levels. However, it is still possible to derive some insight into the trade impacts indirectly by comparing the effects of similar changes in their respective indices. Considering crops for which greater heterogeneity and stricter MRLs both decrease bilateral trade, and comparing a 1-quartile increase in trade restrictiveness from the median index value (moving from the 50th to the 75th and 25th quartiles for heterogeneity and stringency, respectively), the effects of the change in heterogeneity were larger than the effects of the change in stringency for about 80 percent of these crops. For beans, for example, changing the heterogeneity index from the median value to the 75th percentile would decrease bilateral trade by 25.31 percent. By comparison, changing the stringency index from the median value to the 25th percentile would decrease trade by 19.02 percent. The relative effects vary significantly across crops. Notably, this comparison is subject to important caveats. Principal among them is that while this is a comparable change in terms of their respective distributions, the implied changes in the MRLs underlying both indexes may not be equivalent. Thus, this comparison should not be considered a definitive reflection of the relative impacts of any particular MRL policy change. A direct comparison would consider the effects of a specific change in MRLs, which could be translated into corresponding changes in each of the two indices. However, this approach also presents challenges and would be dependent on the crop, the country pairs chosen, and the MRL change.

unaffected by import MRL stringency, while tomatoes and grapes are unaffected by MRL heterogeneity.[447]

Table 3.7 Estimated effects of MRLs on bilateral trade values for the 30 largest crops by value, sorted from largest to smallest

Note: Some values in cells are marked with footnote number 1, meaning the p-value for that estimate exceeds 0.1. Other cells are labelled with stars; three stars attached to estimate values indicate that the p-value is for that estimate is below 0.01. A cell labelled with two stars indicates that the p-value of that estimate is between 0.01 and 0.05. and a cell labelled with one star indicates the p-value of the estimate is between 0.05 and 0.10. P denotes the probability that the true population value is equal to zero (i.e. that the measure has no impact on bilateral trade). Note: n.e.s. means not elsewhere specified.

Crop	Importer MRL stringency estimate	Importer MRL stringency statistical significance	Importer MRL stringency standard Error	MRL heterogeneity estimate	MRL heterogeneity statistical significance	MRL heterogeneity standard error
Maize	1.191	***	0.105	-0.589	***	0.087
Wheat	0.473	***	0.108	-0.388	*	0.209
Soybeans	1.248	***	0.334	-0.882	***	0.259
Potatoes	0.070	*	0.037	-0.384	***	0.120
Tomatoes	0.414	**	0.166	-0.091	1	0.107
Fresh vegetables, n.e.s.	0.545	***	0.083	-0.252	***	0.057
Grapes	0.221	***	0.015	0.008	1	0.087
Apples	-0.028	1	0.117	-0.283	***	0.073
Bananas	0.499	**	0.204	-1.143	***	0.166
Watermelons	1.232	***	0.293	-0.847	***	0.162
Onions, dry	0.551	***	0.172	0.219	***	0.038
Rapeseed	0.301	1	0.223	-0.338	**	0.164
Cucumbers and gherkins	1.521	***	0.204	-0.446	***	0.162
Barley	0.149	*	0.080	-0.377	***	0.085
Beans, all	0.657	***	0.072	-0.287	***	0.057
Mangoes, mangosteens, guavas	0.545	***	0.186	-0.956	***	0.147
Chilies and peppers, green	-0.195	1	0.345	0.031	1	0.068
Sweet potatoes	-1.788	*	1.034	-0.271	1	0.202
Oranges	-0.275	*	0.143	-0.586	***	0.101
Coffee, green	-0.263	1	3.300	-0.270	***	0.066
Olives	0.745	***	0.242	-1.051	***	0.204
Tobacco, unmanufactured	0.695	1	0.548	-0.081	***	0.014
Garlic	0.111	***	0.056	-0.633	***	0.068
Cabbages and other brassicas	0.645	***	0.089	0.028	1	0.057
Eggplants	2.309	***	0.414	-0.517	**	0.211
Peaches and nectarines	0.113	**	0.056	-0.296	***	0.100

[447] The impact of EU MRL changes on the U.S. apple and pear sectors, particularly the diversion of U.S. pear and apple exports to other export markets, is discussed in greater detail in chapter 2 of this report.

Crop	Importer MRL stringency estimate	Importer MRL stringency statistical significance	Importer MRL stringency standard Error	MRL heterogeneity estimate	MRL heterogeneity statistical significance	MRL heterogeneity standard error
Sunflower seed	0.402	***	0.068	-0.566	***	0.082
Lettuce and chicory	0.092	**	0.039	-0.126	***	0.047
Pears	-0.110	[1]	0.107	-0.108	[1]	0.085
Tangerines, mandarins, clementines, satsumas	-0.39	***	0.100	-0.195	***	0.072

Source: USITC estimates.

Finally, it must be emphasized that these described effects are only the direct effects of the policy changes and do not capture many other compounding and offsetting effects that accompany the direct effects. For example, these effects do not capture changes in global prices and purchasing power or trade creation and diversion that may act to offset some of the direct effects of the policies (several of these compounding and offsetting effects are discussed in greater detail in the case study chapter of this report). For this reason, these direct effects should be considered only a part of the full impact of the effects of MRLs. To provide a more complete picture of the total effects of lowering MRLs, a simulation model that captures more of these interconnected relationships is used. The results of this model are presented in the next section.

Simulating the Global Effects of MRL Reductions

The empirical model is well suited to analyzing the direct effects of MRLs on individual trade flows. However, it is not able to capture the full set of direct and indirect effects of MRLs. For example, when market A lowers its MRLs on imports, market B experiences direct effects in the form of added challenges and costs of exporting its goods to market A. The empirical model estimates these direct effects based on past changes to MRLs. However, the lowering of MRLs has a broader range of impacts. For example, market A's increased cost of importing from market B may make other countries relatively more attractive to trade with. Likewise, market B, which faces new barriers to trade in market A, may find alternative export destinations relatively more attractive in terms of trade costs and prices and may shift its trade to other countries. Jointly, these effects may impact the prices and trading patterns throughout the rest of the world to varying degrees. Unlike the empirical model, the simulation gravity model reflects these more layered, compounding relationships and is therefore better able to capture a fuller range of impacts from changes in MRLs.

Compared to the empirical model, the simulation model adds two primary additional types of relationships to the model. First, it adds indices of consumer and producer prices for all countries in the model, incorporating both domestic goods and imports.[448] These price indices capture the relationships

[448] The empirical gravity model captures and controls for the effects of relative prices in each market through the inclusion of importer-year and exporter-year fixed effects. However, it is not able to estimate the relationship between the MRL indices and the prices in each market. The extensions of the model in the simulation version make it possible calculate this important relationship.

between the prices in one market and the prices and policies in all other countries. The inclusion of prices in this way allows the model to capture several important multilateral influences in trade. For example, if two countries become more open to one another as a result of changes to their MRLs or other policies, they also become relatively more closed to the rest of the world by comparison. These multilateral changes in relative openness can have large impacts on trade creation with each other and trade diversion with the rest of the world. Second, it estimates impacts on factory gate prices, which represent the prices received by producers in each market, in order to determine their relationship with MRLs.[449] These additional relationships allow the simulation to capture a broader range of effects that MRLs have on countries. The inclusion of prices also allows for the estimation of welfare effects in the form of changes to purchasing power. Depending on the relative changes in consumer and producer prices (terms of trade), each country may become relatively wealthier or poorer, which further impacts their trading patterns.

The simulation model is a standard, gravity-based trade model used extensively in the economic literature.[450] Recent studies have used similar models to study numerous types of trade policies, such as free trade agreements,[451] China's Belt and Road Initiative,[452] Brexit,[453] and food safety requirements.[454] Trade policies are measured empirically using an econometric gravity model and implemented in the simulation model as part of the bilateral trade costs between markets. Changes in policies alter these trade costs, which further impact prices, trading behavior, and welfare in each market.

To demonstrate the global impacts of lowering MRLs, the MRL indices described above are altered to reflect a counterfactual schedule of MRLs. As discussed above, the counterfactual MRLs reflect a hypothetical scenario in which the EU would reduce its MRLs by 90 percent. Due to computational requirements, this simulation is conducted on three prominent specialty crop groups: tropical fruit, temperate fruit, and fresh and dried beans and peas.[455] These selections reflect specifications in the USTR's request that the report, to the extent possible, include effects on producers in markets with tropical climates where producers are subject to high levels of pest and disease pressure and also to include effects on U.S. producers of specialty crops.

Simulation Results

In this section, the results from the three simulations are presented. As discussed above, the simulations estimate the effect of a hypothetical scenario in which EU MRLs are lowered by 90 percent. This policy

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[449] Within the model, baseline factory gate prices are normalized to 1, and percentage changes are estimated.
[450] For a technical description of the model, see appendix F and Yotov et al., "An Advanced Guide," 2016.
[451] Anderson and Yotov, "Terms of Trade," 2016; Baier, Yotov, and Zylkin, "On the Widely Differing Effects of Free Trade Agreements," 2019.
[452] Kohl, "The Belt and Road Initiative's Effect," 2019.
[453] Brakman, Garretsen, and Kohl, "Consequences of Brexit," 2018.
[454] Zongo and Larue, "A Counterfactual Experiment," 2019.
[455] The aggregate crop groups were derived from the original crop groups based on the following categorization. Tropical fruit includes avocados; bananas; cashew apple; cocoa, beans; coconuts; coffee, green; dates; figs; fruit, tropical fresh not elsewhere specified (n.e.s.); grapefruit (including pomelos); kiwi fruit; lemons and limes; mangoes, mangosteens, and guavas; papayas; pineapples; plantains and others; and tangerines, mandarins, clementines, and satsumas. Temperate fruit includes apples; apricots; blueberries; cherries; currants; peaches and nectarines; pears; persimmons; and plums and sloes. Fresh and dried beans and peas includes all beans and all peas.

change would impact the MRLs for both EU members that set the standards and numerous other "EU-following" markets that rely at least partially on EU standards for their own MRL policies. This policy change is also informative, since many exporting producers noted that they farm to the lowest MRL level (which has frequently been reported to be the EU's) in part because they cannot segregate crops at the point of production or storage.[456]

In all simulations, the results reflect several compounding effects from the change in MRLs. First, based on the MRL stringency index, the change in MRLs would affect the ability of EU and EU-following markets to import, regardless of the market from which they source. Second, based on the MRL heterogeneity index, individual bilateral pairs might face higher or lower costs of trading, depending on whether their MRLs became more or less harmonized as a result of the change. These changes in MRL heterogeneity might either enhance or mitigate the effects of MRL stringency, depending on the crop and the market pair. Third, the magnitudes of these effects would be closely connected to the position of each market in the global market as a producer/consumer and importer/exporter, as well as the extent to which they trade with EU and EU-following markets. Markets that extensively use EU MRLs or export to the EU would experience the largest impacts, while markets with limited exposure to EU MRLs or the ability to shift to alternative partners would be largely insulated from the policy change.

To perform the simulations, the MRL stringency and heterogeneity indices from the econometric gravity model were modified to reflect a hypothetical 90 percent reduction in EU MRLs, and new bilateral trade costs were estimated based on these modifications. The simulation model was solved twice: once using the trade costs estimated using the actual MRLs, and a second time using the trade costs estimated using the hypothetical MRLs. The differences in the two solutions provided the estimated effects of the policies. Because the simulations were based on three crop groups that were more aggregated than any of those analyzed in the previous section, a separate set of econometric estimates were derived for each simulation. These estimates are described for each simulation below and presented fully in appendix F. The simulations were based on trade and production in 2016, the latest year for which the necessary data were available. Thus, the results should be interpreted as the estimated impacts of the EU reducing its MRLs in 2016.

The results for each simulation describe the likely impacts of the policy change on several indicators. The first three categories of results—factory gate prices, consumer prices, and terms of trade—describe the likely impact on prices. Factory gate prices reflect the prices received by producers in each market. Consumer prices reflect the prices paid by consumers in each market. The terms-of-trade results reflect both consumer and producer prices and provide a measure of the impacts on citizens more broadly.[457] A relatively simple interpretation of the terms of trade is that it reflects the purchasing power of citizens who earn income based on factory gate prices and spend that income at consumer prices within each

[456] As discussed below, the simulations are based on data from 2016. For this reason, the United Kingdom (UK) is treated as a member of the European Union (EU) with respect to the hypothetical scenario throughout. Additionally, at the time of writing, the UK retained EU MRLs for most products following its departure from the EU, including those analyzed here. Government of the UK, HSE, "EU Maximum Residue Levels (MRLs)—Basic Guidance."

[457] Specifically, "terms of trade" is defined here as the ratio of factory gate prices received by producers to the prices paid by consumers in each market. Yotov et al., "An Advanced Guide," 2016. This definition is similar to the more common definition, which is the ratio of export prices to import prices, but differs slightly because it considers the prices of both domestic and foreign shipments.

market. If the terms of trade has increased, it means that citizens have greater purchasing power because consumer prices have fallen relative to producer prices. If it has decreased, consumers in the market face lower purchasing power because the price of consumption has risen relative to factory gate prices and therefore relative to their income. The remaining results characterize the imports and exports of each market. These results reflect several factors, including trade creation and diversion, changes in the prices of goods, and changes in wealth and demand.[458]

Tropical Fruit

The empirical gravity model found that MRL heterogeneity has had a trade-decreasing impact on tropical fruit trade, while MRL stringency has had an foreign import-increasing impact.[459] Table 3.8 presents the estimated impact of reducing EU MRLs on tropical fruits by 90 percent on select markets, which are based on the previously discussed empirical estimates.[460] A variety of tropical fruits are included in this broad crop group, including bananas, citrus fruits, and coffee, among others. Citrus fruits account for most of the U.S. and EU production of “tropical fruit” as defined for the purpose of this analysis, with Spain, Italy, and Greece leading in the production of such fruit in Europe, and California and Florida supplying most U.S. production. Coffee, included in this category, and other tropical fruits are important crops for developing countries like Colombia and the Philippines.

Table 3.8 Simulated effects of lowering EU MRLs by 90 percent on tropical fruit for selected markets, by percentage change in factory gate price, percentage change in consumer price, terms of trade, exports, and imports, and by change in the value of exports and imports (thousand dollars)

Note: This table depicts the results for selected markets. A full set of results covering all 31 markets in the model is presented in appendix F. This aggregate crop group includes avocados; bananas; cashew apple; cocoa beans; coconuts; coffee, green; dates; figs; fresh tropical fruit not elsewhere specified (n.e.s.); grapefruit (including pomelos); kiwi fruit; lemons and limes; mangoes, mangosteens, guavas; papayas; pineapples; plantains and others; and tangerines, mandarins, clementines, and satsumas.

	Factory gate price change (percent)	Consumer price change (percent)	Terms of trade change (percent)	Exports change (percent)	Imports change (percent)	Exports change (1000 $)	Imports change (1000 $)
European Union							
France	-0.40	-1.96	1.60	14.08	1.67	41,885	24,030
Germany	-1.86	-2.06	0.20	22.62	-1.38	184,133	-41,452
Greece	-0.49	-1.26	0.77	15.12	2.05	10,962	3,466
Italy	-1.34	-1.76	0.42	18.80	0.84	96,330	13,432
Spain	1.71	1.32	0.38	3.14	28.65	67,711	298,130
Rest of World						,	
Argentina	-0.53	-0.38	-0.15	-1.75	-3.72	-4,770	-4,111
Brazil	0.06	0.06	0.00	-0.68	0.16	-28,455	60

[458] It should be noted that the underlying trade data may include transshipments in some cases. Estimated changes in imports and exports may, therefore, reflect increases in transshipments, at least in part. For example, the increase in tropical fruit exports from Germany, which is not a producer of tropical fruits but does show exports in the data, is one such case in which the estimated growth likely derives from transshipments.

[459] The estimate for MRL heterogeneity was −0.252 (standard error of 0.039) and for MRL stringency was −0.260 (standard error of 0.075).

[460] The table depicts the results for the most impacted countries. A full set of results covering all 31 countries in the model is presented in appendix F.

	Factory gate price change (percent)	Consumer price change (percent)	Terms of trade change (percent)	Exports change (percent)	Imports change (percent)	Exports change (1000 $)	Imports change (1000 $)
Canada	0.11	0.12	-0.01	-0.88	0.13	-441	1,921
Chile	0.17	0.15	0.01	-0.50	1.95	-3,257	909
China	0.09	0.09	0.00	-0.35	0.02	-3,286	219
Colombia	0.20	0.20	0.00	-0.20	1.25	-5,633	91
Egypt	0.79	0.83	-0.03	-3.30	-1.97	-1,716	-1,267
India	0.12	0.12	0.00	-0.08	0.59	-315	665
Indonesia	0.15	0.15	0.00	-0.11	0.44	-1,217	824
Israel	0.03	0.03	0.00	-0.70	-0.30	-2,254	-136
Japan	0.13	0.13	0.00	-2.34	0.16	-84	3,269
Morocco	-1.17	-1.10	-0.07	-3.10	-7.64	-10,714	-5,092
Philippines	0.33	0.33	0.00	0.17	2.06	2,076	2,992
Thailand	0.13	0.13	0.00	-0.14	0.26	-1,239	935
Turkey	-2.20	-1.96	-0.25	-6.26	-15.50	-24,098	-19,634
United States	**0.09**	**0.09**	**0.00**	**-0.39**	**0.12**	**-3,708**	**8,248**

Source: USITC estimates.

The tropical fruit simulation highlights several notable effects of lowering EU MRLs on this crop group. First, EU countries would experience large percentage increases in their exports of tropical fruit as their cost of exporting would become lower. This reduction in the cost of exporting would be due to the lower EU MRLs, which would make it easier for EU countries to export to most markets, as the new MRLs would meet a greater number of foreign MRLs. In other words, by lowering their domestic limits, EU-grown crops would automatically satisfy a greater number of foreign requirements, thereby lowering heterogeneity and the difficulty of satisfying import requirements. Spain in particular, given its relatively high exports and the markets to which it exports, would experience large increases in the value of its exports. While each EU country has the same MRLs, they have different products and export partners and responses, which drives the differences in trade outcomes. Second, the effect of the policies on EU imports would be more nuanced. Because the MRL stringency and MRL heterogeneity effects act in different directions for the tropical fruits crop grouping, their combined effect would depend on each exporting market.

For some countries, such as France and Spain, the change in MRLs would lead to a greater level of foreign imports. This would largely stem from a particularly high increase in purchasing power within these countries, as evidenced by the relatively large increases in their terms of trade. For these countries, reductions in consumer prices, due partially to the estimated import-enhancing effects of greater MRL stringency for tropical fruit, would be large enough to increase consumer purchasing power, even in cases where factory gate prices would decline. As consumers are able to purchase and consume more, they would allocate some of those gains to buying more produce from foreign growers. For other EU countries, such as Germany, imports would decline because these countries would experience limited changes in purchasing power and increased MRL heterogeneity with important trading partners.

For non-EU markets, the effects would generally be smaller. For example, the United States and Colombia would both experience small increases in factory gate prices and similarly limited changes in imports and exports because in most cases, non-EU markets located far from Europe could shift to alternative trade partners. For other non-EU markets at Europe's periphery, such as Morocco and Turkey, the changes in MRLs would have relatively large and negative impacts on their exports, imports, and prices. In addition to close proximity, this is due to the fact that both countries have existing MRLs quite similar to those in the European Union. The reduction in EU MRLs, assuming that neither Morocco nor Turkey adjusted their policies as well, would result in their experiencing relatively large increases in MRL-related trade costs with many of their most important trading partners. Based on these findings, it is likely that other markets highly dependent on the EU as a leading export market—and whose MRLs are likewise aligned with those of the EU—would exhibit similar relationships.

Temperate Fruit

The empirical gravity model of temperate fruits found that MRL heterogeneity has had a trade-decreasing impact on temperate fruit trade and that stringency has had an import-decreasing impact.[461] Table 3.9 presents the estimated impact of reducing EU MRLs by 90 percent on select markets.[462]

Table 3.9 Simulated effects of lowering EU MRLs by 90 percent on temperate fruit for selected markets, by percentage change in factory gate price, percentage change in consumer price, terms of trade, exports, and imports, and by change in the value of exports and imports (thousand dollars)

Note: This table depicts the results for selected markets. A full set of results covering all 38 markets in the model is presented in appendix F. This aggregate crop group includes apples; apricots; blueberries; cherries; currants; peaches and nectarines; pears; persimmons; and plums and sloes.

	Factory gate price change (percent)	Consumer price change (percent)	Terms of trade change (percent)	Exports change (percent)	Imports change (percent)	Exports change (1,000 $)	Imports change (1,000 $)
European Union							
France	1.70	2.28	-0.57	-4.59	-6.85	-28,744	-39,738
Germany	3.70	3.93	-0.22	-17.44	3.75	-41,627	61,415
Italy	0.86	1.16	-0.30	-0.55	-16.46	-6,272	-52,404
Poland	2.10	2.61	-0.50	-5.34	-6.16	-8,560	-10,484
Romania	2.44	2.75	-0.30	-9.17	-4.44	-674	-4,336
Spain	0.34	0.50	-0.16	1.51	-20.93	23,605	-70,570
Rest of World							
Argentina	-0.18	-0.18	0.00	-0.22	-0.38	-1,070	-18
Chile	-0.19	-0.19	0.00	0.12	-0.51	2,535	-25
China	-0.15	-0.15	0.00	-0.25	-0.26	-2,400	-2,420
Morocco	-0.36	-0.21	-0.15	-2.16	-4.11	-1,472	-801
South Africa	0.00	0.00	0.00	1.93	1.36	7,562	58
Switzerland	0.25	0.53	-0.28	-3.49	-1.15	-58	-1,869
Turkey	-0.35	-0.30	-0.05	-1.59	-5.96	-3,423	-540
United States	**-0.17**	**-0.17**	**0.00**	**-0.25**	**-0.31**	**-4,089**	**-4,051**

Source: USITC estimates.

As they did with tropical fruit MRLs, EU countries would also experience the largest effects of the changes in temperate fruit MRLs. Most EU countries would experience relatively large increases in the prices received by their producers. However, consumer prices would rise more than producer prices,

[461] The estimate for MRL heterogeneity was −0.076 (standard error of 0.042) and for MRL stringency was 0.125 (standard error of 0.034).

[462] The table depicts the results for the most impacted countries. A full set of results covering all 38 countries in the model is presented in appendix F.

resulting in less favorable terms of trade and lower purchasing power for consumers. Unlike trade in tropical fruit, which would experience some trade cost-reducing effects from the change in the EU's MRL stringency index, an increase in MRL stringency for temperate fruit would raise trade costs for temperate fruit and would compound the increase in MRL heterogeneity with most partners. As a result, consumer prices in countries like Germany would rise by more than factory gate prices, resulting in lower purchasing power within the market.

Although EU countries would face relatively lower costs to export temperate fruit, the value of foreign exports of these goods would fall for almost all EU countries. In almost all cases, EU countries would turn their purchasing inward, buying much more domestic produce. This shift also explains much of the reductions in foreign imports for most EU countries. However, some countries, such as Germany, would experience a relatively larger decrease in trade costs and increase in factory gate prices, which would result in them importing more. Notably, though, this growth would be primarily driven by increases in imports from other EU countries—Italy and Spain in particular. Across the European Union as a whole, there would be a small shift in trade inward and away from other foreign partners. Overall, total shipments within the EU (domestic shipments and exports to other EU members) would increase by about 0.46 percent.

For non-EU markets, the effects would again be muted by the fact that the European Union countries are only a part of the global market for temperate fruit. Of these markets, Switzerland would exhibit the largest effects because of relatively extensive trade with EU countries and the fact that Switzerland's MRLs were relatively similar to the EU's before the change but would be much less similar after. That the effects on most non-EU markets would be negative reflects the fact that the EU would participate less in extra-EU trade, which would have few benefits for the rest of the world. The few exceptions are markets like Chile, which would be able to export more to two of its key markets—Germany and the UK. The effects on the United States would be small and negative, though this may vary by crop (low and changing MRLs in the EU are discussed in greater detail for several U.S. crops in chapter 2 of this report). While consumer prices in the United States would decline, these declines would be too small to offset the trade impacts of the rise in export costs and reduction in factory gate prices.

Fresh and Dried Beans and Peas

The empirical gravity model of fresh and dried beans and peas found that MRL heterogeneity has had a trade-decreasing impact on these crops and that MRL stringency has had an import-decreasing impact.[463] Table 3.10 presents the estimated impact of reducing EU MRLs by 90 percent on select markets.[464]

[463] The estimate for MRL heterogeneity was −0.219 (standard error of 0.052) and for MRL stringency was 0.409 (standard error of 0.083).
[464] The table depicts the results for the most impacted countries. A full set of results covering all 34 countries in the model is presented in appendix F.

Table 3.10 Simulated effects of lowering EU MRLs by 90 percent on fresh and dried beans and peas for selected markets, by percentage change in factory gate price, percentage change in consumer price, terms of trade, exports, and imports, and by change in the value of exports and imports (thousand dollars)

Note: This table depicts the results for selected markets. A full set of results covering all 34 markets in the model is presented in appendix F. This aggregate crop group includes fresh and dried beans and peas.

	Factory gate price change (percent)	Consumer price change (percent)	Terms of trade change (percent)	Exports change (percent)	Imports change (percent)	Exports change (1,000 $)	Imports change (1,000 $)
European Union							
France	2.74	3.20	-0.44	3.97	-7.08	8,816	-7,035
Germany	3.99	4.24	-0.24	-3.46	1.67	-1,723	1,632
United Kingdom	4.32	4.39	-0.06	-4.84	3.56	-1,424	5,682
Lithuania	2.49	2.51	-0.02	4.59	-8.70	3,355	-177
Spain	3.56	3.70	-0.13	-1.00	-1.10	-638	-851
Rest of World							
Canada	-0.02	-0.02	0.00	0.37	-0.68	4,555	-1,278
China	0.01	0.01	0.00	-0.16	-0.08	-881	-282
Egypt	0.49	0.54	-0.05	0.02	-7.71	12	-1,557
India	0.00	0.00	0.00	0.61	-0.20	147	-2,068
Russia	0.08	0.07	0.02	0.48	1.28	769	162
Switzerland	0.79	1.24	-0.44	-8.18	-0.49	-23	-81
Thailand	0.01	0.01	0.00	-0.27	-0.22	-87	-28
Turkey	0.42	0.45	-0.03	-6.44	-0.56	-458	-650
Ukraine	0.17	0.14	0.03	1.46	3.12	953	38
United States	**0.01**	**0.01**	**0.01**	**0.19**	**-0.24**	**1,003**	**-760**

Source: USITC estimates.

The simulation results for fresh and dried beans and peas were similar to those for temperate fruit. For most markets, including both EU and non-EU countries, the reduction in MRLs would increase factory gate prices. However, increases in consumer prices would offset the higher producer prices, resulting in lower purchasing power in EU countries and many non-EU markets. These changes in prices would lead to higher exports of fresh and dried beans and peas from some EU countries, such as France and Lithuania, but also in lower imports of these goods. The opposite is true for other EU countries, including Germany and the UK (which retained EU MRLs for most products following its departure from the EU), which would lower exports but increase imports. The differences in the effects between these countries are due to the markets with which each group trades. The reduction in MRLs would disproportionately affect markets to which France, the Netherlands, and Lithuania export, which would result in greater export growth for these three countries than for other EU countries. Across the EU, there was a small shift in trade inward and away from other foreign partners. Overall, total shipments with the EU would increase by about 0.26 percent.

For non-EU markets, the effects would again be much smaller in most cases. However, several non-EU markets would experience small increases in their terms of trade and purchasing power. As a result, some countries, such as Russia and Ukraine, would increase their imports. The increased imports in these countries and certain EU countries would cause other non-EU markets, including Canada and the United States, to increase their exports.

Additional Discussion of the Effects of MRLs on Leading Tropical Fruit Suppliers to the European Union

This section of the report provides additional discussion of specific data used in the empirical gravity model (presented above) for selected leading exporters of certain tropical fruits to the European Union. This section highlights and illustrates certain trends in the number of MRLs available, differences in MRLs, and the stringency of EU MRLs on imports of select tropical fruit products from leading sources. This section focuses on tropical fruit for illustrative purposes; this sector was also selected in part because certain tropical fruits (bananas) were included in the farm-level analyses in chapter 4.

This discussion relies on the data reported in table 3.11, which compares domestic MRLs for leading exporters of select tropical fruits to the EU relative to the MRLs that producers face when exporting these crops to the EU.[465] The primary products covered in the analysis include bananas and plantains; citrus; dates, figs, pineapples, avocadoes, guavas, mangoes, and mangosteens; and unroasted coffee.[466] In this analysis, the leading suppliers of these products to the EU are Brazil (coffee and certain tropical fruits), Colombia (banana and plantains, and coffee), South Africa (citrus fruit), Vietnam (coffee), and Egypt (citrus fruit). These countries are representative of global exporters to the EU in terms of product coverage and MRL stringency and heterogeneity relative to the EU; not all countries in the case studies and farm-level analyses are included. The analysis also includes Codex MRLs that may be used by many exporting markets not specifically analyzed in the gravity analysis.

[465] The data used in this analysis are explained in detail in the section titled "MRL Statistics for Select Countries and Crops," above.
[466] These countries were selected based on EU tropical fruit imports classified in the Harmonized Tariff Schedule of the United States (HTS) under HTS 0803 (banana and plantains, fresh or dried), 0804 (dates, figs, pineapples, avocadoes, guavas, mangoes and mangosteens, fresh or dried), 0805 (citrus fruit, fresh or dried), 090111 (coffee, not roasted, not decaffeinated), and 090112 (coffee, not roasted, decaffeinated).

Table 3.11 Measures of MRL availability, homogeneity, and stringency for selected tropical fruit imported into the European Union from leading exporters, 2016[467]

Note: The primary products covered in the analysis as listed in the Harmonized Tariff Schedule of the United States (HTS) include bananas and plantains (HTS 0803); citrus (HTS 0805); dates, figs, pineapples, avocadoes, guavas, mangoes, and mangosteens (HTS 0804); and unroasted coffee (HTS 090111 and 090112). Note: n.a. means not applicable.

Market supplier	Crop	Number of established domestic MRLs	Established mean domestic MRLs (ppm)	Number of established EU MRLs	Established mean EU MRLs (ppm)	MRL ratio: EU to exporter	Heterogeneity empirical index (base)	Heterogeneity simulation index (90% reduction)	EU stringency empirical index (base)	EU stringency simulation index (90% reduction)
Brazil	Avocados	17	5.16	1,049	0.48	0.58	2.49	3.03	2.36	0.24
	Coffee	130	0.56	1,049	0.58	0.59	3.22	4.48	0.14	0.01
	Dates	0	n.a.	1,049	0.30	n.a.	0	0	2.55	0.26
	Figs	17	0.9	1,049	0.30	.08	2.69	2.91	0.14	0.01
	Mangoes Mangosteens Guavas	47	0.82	1,049	0.32	.50	1.81	2.40	1.32	0.13
	Pineapples	37	1.18	1,049	0.43	.23	4.19	4.75	0.94	0.09
Colombia	Bananas	42	2.18	1,049	0.33	0.43	0.63	1.15	2.69	0.27
	Plantains and others	0		1,049	0.33		0	0	0.27	0.03
	Coffee	16	0.17	1,049	0.58	0.6	0.65	1.54	0.14	0.01
Egypt	Lemons and limes	57	3.21	1,049	0.60	0.16	1.15	1.53	1.19	0.12
	Tangerines, etc.	66	4.33	1,049	0.60	0.12	1.28	1.68	1.32	0.13
South Africa	Lemons and limes	114	4.59	1,049	0.60	0.24	4.77	5.18	1.19	0.12
	Tangerines, etc.	114	4.59	1,049	0.60	0.24	4.86	5.26	1.32	0.13
Vietnam	Coffee	20	0.24	1,049	0.58	0.74	0.74	2.01	0.14	0.01
Codex	Avocados	20	8.93	1,049	0.48	0.56	0.39	1.10	2.36	0.24
	Bananas	54	1.40	1,049	0.33	0.43	0.35	0.97	2.69	0.27
	Coffee	34	0.17	1,049	0.58	0.85	0.26	0.97	0.14	0.01

[467] The MRL ratios reported here are calculated in the same way as those in table 3.4 above.

Market supplier	Crop	Number of established domestic MRLs	Established mean domestic MRLs (ppm)	Number of established EU MRLs	Established mean EU MRLs (ppm)	MRL ratio: EU to exporter	Heterogeneity empirical index (base)	Heterogeneity simulation index (90% reduction)	EU stringency empirical index (base)	EU stringency simulation index (90% reduction)
	Dates	10	20.46	1,049	0.30	0.92	0.59	0.97	2.55	0.26
	Figs	10	50.56	1,049	0.30	0.52	0.55	0.83	0.14	0.01
	Lemons and limes	75	2.92	1,049	0.60	0.35	0.46	0.96	1.53	0.15
	Mangoes, etc.	37	1.43	1,049	0.32	0.25	0.66	1.04	1.32	0.13
	Pineapples	16	1.50	1,049	0.43	0.70	0.35	0.87	0.94	0.09
	Plantains and others	1	2.0	1,049	0.33	1.00	0	1.27	0.27	0.03
	Tangerines, etc.	86	3.75	1,049	0.60	0.25	0.56	1.06	1.32	0.13
Average		42.5	5.50	1,049	0.45	0.47	1.36	1.92	1.21	0.12

Source: USITC estimates.

Number of MRLs

As shown in table 3.11, there are large differences in the absolute numbers of MRLs established in the EU market and in exporting markets. The EU had 1,049 MRLs established for each of these products in 2016, compared with a range from zero MRLs for plantains in Colombia to 130 MRLs for coffee in Brazil, with an average of 43 MRLs available to producers of these crops in these exporting markets.[468] The gravity model simulation results for tropical fruit, described above, indicate that a reduction in all EU MRLs for tropical fruit would have more substantial impacts on EU trade and prices than on non-EU producers. However, the large number of EU MRLs indicate that the reduction or elimination of MRLs for individual key active substances may have little or no impact on its own domestic producers, given the wide variety of pesticide options available to those producers. By contrast, lower income exporting markets frequently have comparatively limited pesticide options due to the challenges associated with registering alternative active substances (see volume 1, chapters 4 and 5). Therefore, elimination of existing pesticide options (either by the exporting market itself or due to the removal of MRLs in a key export destination market, such as the EU) may force producers in these markets to adjust production practices in a way that may increase costs, reduce yields, and impair product quality (which may lower price), by foregoing use of a certain pesticide altogether. These effects are described in greater detail in chapter 4.

Differences in MRL Levels

Differences in the absolute level of MRLs between an importing market and an exporting market could suggest a range of outcomes in cases where an importing market lowers or eliminates an MRL.[469] In cases where differences in existing MRL levels do not currently deter trade, lowering or eliminating an MRL in an import market could cause producers to lose access to that import market or to make adjustments to farming methods and cultural practices that substantially increase costs and/or reduce yields or impair product quality and price. These adjustments to practices can sometimes increase trade between specific partners if some exporters are able to make changes in their production practices while other exporters do not or cannot make changes to qualify product for the import market. These types of issues are discussed in case studies in both volume 1 and this volume.

MRLs in the export markets included in table 3.11 averaged 2.5 ppm, compared with 0.48 ppm for the corresponding EU MRLS.[470] EU MRLs for mangos, mangosteens, guavas, bananas, plantains, and

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[468] Volume 1 describes the extensive scientific processes and requirements that are used to evaluate and establish an MRL. However, the EU also includes MRLs set at the EU's default level (often 0.01 ppm) in its positive list. MRLs set by applying the default MRL are not evaluated via a scientifically based risk assessment and thus are not directly comparable to MRLs that have been established on the basis of a risk assessment. As explained in volume 1, when an active substance is not registered for use in the EU, the EU can set an MRL at the default value, which is the lowest level of analytical determination (LOD) i.e., the lowest level at which the substance can be detected. This level is often 0.01 parts per million (ppm) but may vary. When an active substance is not renewed in the EU, the MRL may also be lowered to the default value.

[469] Lowering or eliminating an MRL could have no effect on trade between the two markets for a couple of reasons. The difference may have already been so large that producers in the export market have chosen not to supply that import market, or producers in various export markets may face different pest pressures and use different pesticide practices.

[470] The Codex MRLs for dates (20.46) and figs (50.56) were excluded from this analysis as being outliers.

pineapples were lower than the average (i.e., more stringent), while the EU MRLs for avocados, coffee, and citrus were higher than the average (i.e., less stringent). The difference between the average MRLs in exporting markets and the EU was 2.02 ppm (i.e., the average EU MRL was lower and thus more stringent);[471] thus, lowering or eliminating MRLs on key substances in the EU used in exporting markets would only increase these differences and would likely require changes in cultural and/or supply chain management practices for these exporters to continue to export to the EU profitably. MRLs in export markets were lower than MRLs in the EU in only 6 of 24 comparisons. Green coffee beans, which are not commercially produced in the EU, represented 4 comparisons, and dates represented the other 2. (Spain is the only EU country with reported production of dates, at less than 2,000 metric tons.) [472]

The ratio of the importer's MRL to the exporter's MRL (see table 3.4 and accompanying text above for a detailed explanation of the MRL ratio) provides a clear visualization of relative MRL levels between specific import markets and export markets. The reason for this is that this ratio was constructed using only pesticide/crop pairs where the exporter had an MRL, thus minimizing the impact of (1) EU MRLs established at the default value or (2) cases where the exporting market did not register a product and where the EU had a higher MRL. Note that as the importer MRL decreases relative to the exporter MRL, producers in the exporting market can (1) alter their production practices, including reducing or eliminating pesticides, to maintain the same level of exports to that import market, or (2) keep using pesticides at the same levels and shift exports to alternative markets. In all cases reported in table 3.11, the ratios are less than 1, indicating that the EU MRL is more stringent than the exporter's MRL. The average ratio of 0.47 indicates that the average EU MRL on this list of tropical products is 53 percent more stringent than the average exporter MRLs for the same set of products.

Heterogeneity and Stringency Indices

The specific heterogeneity and stringency indices used in the empirical model (the base case) and the simulation model's scenario (90 percent reduction) are included in table 3.11 to provide a sense of how the MRL values for this set of tropical products and exporting markets relate to the variables used in gravity analysis. The EU product stringency indices are the same, regardless of source MRL levels, because this index considers only the stringency of importer MRLs. Differences between specific pairs of markets are addressed by the heterogeneity indices.

The stringency index is country-specific for the EU, the importer. It is not a pairwise comparison. Rather, it represents the variable used in the gravity analysis to compare how relatively restrictive EU (importer) MRLs were on trade.[473] The mean stringency for importing these tropical products to the EU was 1.21. MRLs were the most stringent for coffee, plantains, figs, and pineapples, while they were least stringent for citrus, avocados, dates, and bananas. In these comparisons, the single most stringent index measure for EU imports was on coffee, where the index was 0.14. As the same index applies regardless of the source, coffee exports from Vietnam, Colombia, Brazil, and countries defaulting to Codex MRLs were all subject to this same stringency when imported into the EU. In these comparisons, the EU stringency

[471] Again, this value excludes dates and figs, as Codex MRLs for these products appear to be outliers.
[472] FAO, FAOStat database. Based on FAOStat crop production data for dates, Spain produced less than 2,000 mt of dates per year during 2015–18. (accessed September 27, 2020)
[473] For specific effects of stringency on trade, see the descriptions and discussions of the gravity analysis related to table 3.7 elsewhere in chapter 3 and in appendix F.

index was the least stringent (2.69) for banana imports, regardless of source, such that bananas exported from Colombia (and countries that default to Codex MRLs) to the EU both face this same measure of stringency.

When the full tropical product group was analyzed in aggregate in the gravity simulation, the baseline stringency index for the simulation was 1.19, while the (counterfactual average) 90 percent reduction index was 0.12. By comparison, the average baseline stringency index for this subset of tropical fruits is 1.21, while the (counterfactual) 90 percent reduction index was 0.12. Thus, the two indices for this subset of tropical fruit products are comparable to the stringency index for the full set of tropical fruits, which covers more markets and more products. Put in context, the average simulation MRL for EU imports (following the 90 percent reduction) of these tropical fruits was more stringent (0.12) than the current most stringent MRLs, which are the baseline MRLs (0.14) for EU coffee imports (which represents current MRLs).

The heterogeneity index represents a pair-specific comparison between the MRLs of the EU as an importer and specific exporting markets. This index, listed in table 3.11, represents a measure of how different or diverse EU MRLs were from MRLs for corresponding products in exporter markets.[474] In these comparisons, the heterogeneity index shows the highest degree of heterogeneity (the largest amount of difference or diversity) for MRLs in the EU relative to MRLs in South Africa on tangerines, mandarins, and clementines (4.86) and lemons and limes (4.77).

The EU and Codex MRLs were generally the least heterogeneous (least divergent), which is consistent with the EU's reported objective to align its MRLs with Codex MRLs, as related in volume 1.[475] With minor exceptions, Codex MRLs for these products are closer to the EU's than any other source. The average homogeneity index for the subset of tropical products between each country market and the EU in table 3.11 was the smallest (least diverse) between Codex and the EU at 0.46, increasing to 0.64 between Colombia and the EU, 1.22 between Egypt and the EU, 2.88 between Brazil and the EU, and 4.82 between South Africa and the EU.[476] For crop-specific examples, this table shows that the heterogeneity indices for EU and Codex MRLs ranged from 0.26 for coffee to 0.66 for mangos, mangosteens, and guavas; by comparison, the heterogeneity index was 3.22 for coffee from Brazil and 1.81 for mangos, mangosteens, and guavas, from Brazil. The average heterogeneity index for this set of tropical fruits and leading exporters (those listed in table 3.9) to the EU was 1.36 in 2016 and increased to 1.92 following a 90 percent reduction in EU MRLs.

Figure 3.1, found at the beginning of this chapter, demonstrates how stringency and heterogeneity affect trade. The tropical fruits in table 3.11 represented in this figure include bananas, mangoes, tangerines, and coffee. Bananas and mangoes are in the upper left quadrant of the figure, implying that more stringent importer MRLs (lower index numbers) and more divergent MRLs (higher index numbers)

[474] For specific effects of heterogeneity on trade, see the descriptions and discussions of the gravity analysis related to table 3.9 elsewhere in chapter 3 and in appendix F.
[475] The EU will align its MRLs with Codex MRLs subject to these three conditions: (1) the EU already sets MRLs for the commodity under consideration; (2) the existing EU MRL is lower than the Codex MRL; and (3) the Codex MRL is acceptable to the EU with respect to areas such as consumer protection, sufficient supporting data, and extrapolations. The EU expresses reservations about Codex MRLs if condition 3 is not met. European Commission, written submission to USITC, December 13, 2019, 18.
[476] Averages not shown on table.

are associated with lower imports for these two fruits. Coffee and tangerines are in the lower left quadrant, implying that for these two products, more stringent importer MRLs are actually associated with higher imports, and that more divergent MRLs are associated with lower imports; thus, these factors may somewhat offset each other.

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Chapter 4
Effects of MRL Policies on Production, Income, and Individual Farms

Overview

This chapter includes quantitative analyses that focus on the diverse effects of low and missing MRLs on production and farm income on the national level and on the farm level. Two separate analytical approaches, a supply response analysis and a farm income statement analysis, were applied to specific specialty crop sectors: banana production in Costa Rica and tart cherry production in the United States. These crops and countries were chosen for these analyses because they represent production of tropical and temperate fruits in countries with different income classifications and extend both the foreign and domestic case study analyses conducted in this report (see *Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels, Vol. 1*, chapter 5, and chapter 2 of this volume) and the gravity modeling analysis of trade and price effects in chapter 3. The results of the analyses, while specific to individual industries, illustrate some of the effects of MRL reductions that have been identified across multiple exporting industries in both volumes of this study.

The first approach—the supply response analysis—estimates the impacts of changes in farm gate prices on agricultural output. Specifically, it is a partial equilibrium analysis that describes the effects of sustained price changes on agricultural production to assess how crop production may shift in response to those price changes. The second approach, a farm income statement analysis based on a pair of hypothetical farms, is used to understand the practical impacts of MRL changes on individual farms producing these specialty crops in both a small, upper-middle-income country and in the United States. The farm income statement analysis allows the estimation of effects of foreign MRL removals on growers' financial budgets as a result of yield losses, abandonment of export markets, risks of noncompliance with import market MRLs, increased input costs, and/or creation of market opportunities.

These analyses supplement the gravity models of trade and price effects of MRLs described in chapter 3. The simulation gravity model described in that chapter, while effective at measuring many of the effects of MRL changes on trade and prices, only reflect impacts on production and income to the extent those find expression in changes in trade volume or prices.[477] This chapter's analyses seek to more explicitly quantify the impacts of MRL changes on production and farm income. In addition, this chapter's farm income analysis seeks to quantify several of the factors that may influence gravity model results, such as costs imposed by yield losses, pesticide use changes, or compliance costs. As described in chapter 3, the impact of changes in MRLs on farmer costs may not be fully captured within the gravity model when

[477] As described in chapter 3, the simulation model relies on a fixed agricultural production assumption, representing a short-term picture of the world in which prices can adjust to changes in MRLs but the quantity produced cannot. The empirical gravity model provides an indication of the direction and extent of direct trade impacts of MRLs between bilateral countries in the short term, but likewise does not address other indicators.

MRLs change substantially from historical levels (e.g., through removal of MRLs for pesticides used commonly in production).

As a result of changes in MRLs and MRL reductions in key export markets, individual crop sectors in specific countries may experience trade, price, and cost effects that are distinct from those of broader crop groupings covered in the simulation gravity model. Therefore, while this chapter's supply response analysis directly uses price effects generated from the simulation gravity model, both analyses in this chapter also use an alternative set of price assumptions. In addition, this chapter's farm income statement analysis examines cost effects at the farm level for two industries.

Summary of Production, Income, and Farm-level Effects of MRLs

Table 4.1 summarizes the results of the supply response analysis and the farm income statement analyses for bananas produced in Costa Rica and tart cherries produced in the United States. The supply response analysis considers these producers' reactions to changes in global prices for their crops. The supply response analysis indicates that, for these industries, changes in prices alone would likely result in relatively modest production impacts, particularly if these industries are able to adjust by shifting export destinations in a global market. However, if the industries face severe trade impacts involving key export destinations and have few alternative markets, price reductions and corresponding supply reductions would likely be more substantial.

The farm income statement analysis shows that changes in MRLs in export markets (and MRL removals in particular) can have a range of effects that can impact a farm's production, costs, and profitability. When MRL removals occur in markets that farmers rely on for a large portion of their sales, they may change their production practices by switching to other pesticides, which are frequently more costly, less effective, or both. The farm income analysis presented here indicates that this can undermine a farmer's profitability. In the presentation of a more catastrophic scenario related to MRL removals, a lack of alternative pesticide products, or limited integrated pest management (IPM) options, would make production infeasible. Removal of all pesticide options over a short period of time is not a likely scenario but represents the longer-term concerns of industries in which MRL removals in key markets are resulting in greater pest resistance to the few alternative pesticides available. Even in cases where most of a farm's sales are made domestically, the decision to forego exports rather than implement these types of pesticide and farm practice changes could be the difference between profitability and unprofitability in years when domestic prices are low. Noncompliance with MRLs in foreign export markets presents a highly risky scenario that could substantially reduce a farmer's profitability, even if noncompliance occurs for only a small portion of their overall sales. Finally, there may be opportunities for well-positioned farms to improve their prices and operating income in cases where they are uniquely capable of meeting foreign MRLs.

Table 4.1 Summary of effects of MRL changes on production and farm income

Economic effects	Costa Rica bananas	U.S. tart cherries
Supply response analysis		
Change in output caused by MRL reductions and assumed limited price effect (percent change in quantity)	0.2	-0.1
Change in output caused by MRL reductions and assumed substantial price reduction (percent change in quantity)	-4.8	-2.4
Farm income statement analysis		
Farm production effects of MRL removals (percent change in quantity)	-57.4 to -6.3	0
Farm cost effects of MRL removals (percent change in value)	-13.7 to 2.7	-0.3 to 10.1
Operating income margin effects identified (percentage point change)	-6.3 to -68.1	-56.0 to 16.9

Source: USITC estimates.

MRL Effects on Banana Producers: Costa Rica

The quantitative analytical approaches covered in this chapter are applied to the Costa Rican banana industry to assess its response to a substantial reduction (or removal) of MRLs in a key export. The Costa Rican banana industry was chosen because it represents tropical fruit production in a small upper-middle-income country and because the industry was included in a case study in volume 1 that demonstrated significant MRL-related challenges. While the Costa Rican economy and its agricultural sector have both diversified in recent years, traditional tropical crops such as bananas and coffee remain important sources of income in rural areas. And like other tropical crops, bananas are vulnerable to a number of diseases and pest infestations, since tropical growing conditions can increase pest pressure. Growers in these regions depend on access to pesticides and MRLs that reflect their pesticide use patterns. However, because Costa Rica (like many other exporters of tropical produce) relies heavily on the European Union (EU) export market, and because crop segregation is not feasible in Costa Rica, MRL use in the Costa Rican banana industry (and its resulting impact on domestic production) is largely driven by EU MRL policies. Because bananas are highly perishable, grow quickly, and are harvested frequently, it can be particularly difficult for growers to meet low export market MRLs. Also, reductions/removals of MRLs and associated reduction in pesticide use can threaten the IPM systems that are critical to maintaining crop yields and profitability.

As demonstrated in chapter 3, increased stringency and heterogeneity (divergence) in importer MRLs are associated with reduced bilateral trade in bananas between countries. With respect to tropical fruit as a whole, the simulation gravity model found that a substantial decline in MRLs within a major global market (the EU) would likely also cause modest price increases for most non-EU exporters of tropical fruit. Based on the supply response analysis in this chapter, modest price increases such as those derived from the gravity model for tropical fruit would cause Costa Rican banana production to slightly increase in response to those higher prices. Relatively stable trends in production and prices would occur notwithstanding shifts in bilateral trade between Costa Rica and trading partners. However, if such an MRL reduction has more of a price-decreasing effect for Costa Rican bananas than for tropical fruits as a whole due to the dependence of the Costa Rican industry on sales to the EU, production would also likely decline at a similar rate in response.

A farm income statement model focusing on a hypothetical banana farm in the Siquirres region of Costa Rica demonstrates the tangible impacts of various alternatives available to a banana producer when faced with MRL changes in the EU market. Based on evidence that the EU market has been and will remain critical for Costa Rican banana producers, this analysis assumes that the banana farm will continue to adapt its production practices to meet EU MRLs. If MRLs for all pesticides are suddenly removed or reduced to the limit of determination of 0.01 parts per million (ppm), as has been the recent trend for EU MRLs on important pesticides used in producing bananas, then the yield losses could be catastrophic, causing the banana farm's income to become deeply negative. Under a more sequential scenario where one MRL is removed at a time, the banana producer's profits would be reduced even if they could find alternative pesticides to react to pest pressures.

MRL Effects on Tart Cherry Producers: United States

The quantitative analyses presented in this chapter are applied to the U.S. tart cherry industry, representing a specialty crop industry in a high-income country with a sophisticated agricultural support network. These industries have large domestic consumer markets but frequently face challenging pricing conditions in those markets due to stable or decreasing demand, competition with imports, and variation in harvests, among other factors contributing to price volatility. As a result, export markets are important for U.S. producers, even if most of the specialty crop will be consumed in the domestic market, because the industry relies on export markets for additional sources of revenue. Within this context, reductions in MRLs or the loss of MRLs in important export markets can substantially affect U.S. industries' opportunities, revenues, and costs. This is particularly the case for U.S. industries facing emergent pest pressures, such as that caused by spotted wing drosophila (SWD), a fruit fly, which is discussed in further detail in both the tart cherry and sweet cherry case studies in chapter 2 of this report.

As demonstrated in chapter 3 and appendix F, increased heterogeneity (divergence) in MRLs is associated with reduced bilateral trade in tart cherries between countries.[478] The simulation gravity model results indicate that reductions in MRLs would lead to modest price effects for the broader crop grouping of temperate fruit. Tart cherry production is driven largely by tree-planting decisions made over long periods of time, and therefore changes in price would likely have more muted impacts on output than in other industries where plantings and harvests allow faster adjustment to price changes. As a result, the supply response analysis in this chapter estimates that the price effects derived from the simulation gravity model would cause only a minuscule change in output. Even with more substantial price declines, under the assumption that EU MRLs are more trade limiting for cherries than for temperate fruit as a whole, tart cherry output would decline only slightly for the U.S. industry overall.

A farm income statement model estimates the impact of a range of scenarios on a hypothetical Michigan tart cherry farm when an MRL for an important pesticide for managing SWD is removed from

[478] The effect of MRL stringency was statistically insignificant for tart cherries. See appendix F.

the EU market. Given that export sales represent an important revenue channel for the farm, particularly during years when U.S. price levels are low, producing to the EU MRL presents a possible opportunity but would also result in additional costs associated with use of a more expensive alternative pesticide. Forgoing EU export opportunities and producing to higher MRLs applicable in the U.S. or other export markets could substantially affect profitability if prices in those markets are considerably lower than EU prices. Even if the farm produces tart cherries in compliance with EU MRLs and secures a foreign buyer, a mistake in production, or one MRL exceedance, could have a severely negative impact on income. On the other hand, a farm may find that it is uniquely capable of serving a market with lower MRLs and may therefore realize greater export opportunities and higher prices as a result, which can improve profits.

Supply Response Analysis: Effects of Price Changes on Agricultural Production

Low and missing MRLs in key export destination markets may impact agricultural production if they impact farmers' prices. Higher prices for a specific product increase the incentives for farmers to produce that crop, while lower prices decrease these incentives. Many farmers cannot immediately change production in response to a change in market prices. Agricultural crops tend to be seasonal in nature, with lags between planting and harvesting that can range from months to years and can hinder quick production shifts. For the case studies below, the lag between planting and harvesting falls on the high end for tart cherries and in the mid-range for bananas. However, it is likely that in the long term, sustained price changes would cause changes in agricultural output as farmers make new decisions about planting and harvesting. The supply response analysis measures the long-term potential effects of price changes caused by MRL changes in export markets on the Costa Rican banana and U.S. tart cherry industries. This analysis does not cover the effects of individual farmers' decisions to change pesticide applications in response to changes in MRLs, which may impact crop yields or variable costs and could also therefore impact production and planting decisions: these effects are described in the farm income statement analysis below.

Supply Response Analysis Methodology

In order to estimate the long-term output effects in response to price changes caused by foreign MRL shifts, the supply response analysis approximates the effects of exogenous (externally derived) price changes on agricultural production in the Costa Rican banana industry and the U.S. tart cherry industry. For each industry, changes in price are multiplied by price elasticities of supply (the responsiveness of that industry's output to changes in price) to estimate the supply response.[479] Two types of price shocks are used within this analysis. The first set of price shock inputs is derived from the farm gate price impacts identified by the gravity model simulations for tropical fruit (for the banana industry) and temperate fruit (for the tart cherry industry), both of which were based on a 90 percent reduction in EU

[479] Price elasticities of supply were derived from a review of economic literature involving these crops (or similar crops) in the regions of focus (or similar regions). These are described below.

MRLs.[480] A second set of price shock inputs is also used in this analysis to demonstrate the impact of a more substantial price effect on output.

The first set of price shocks, based on the gravity modeling results, reflect the price effects of lower MRLs on broader groups of crops: tropical fruit and temperate fruit. For these large agricultural industries, there may be substantial increases or decreases in bilateral trade flows for individual crops to individual partners, but these would generally be mitigated by trade diversion and other adjustments such that overall price effects are frequently within 1 percentage point of zero. Use of these simulated farm gate price changes requires an assumption that conditions facing the broader group of crops would be similar for the narrower underlying industries. Using the results for tropical and temperate fruits, the farm gate price impact on Costa Rican bananas would result in an increase of 0.20 percent, while the farm gate price impact on U.S. tart cherries would be a decrease of 0.17 percent.[481]

For several reasons, the price impacts of MRL changes on the individual agricultural industries examined here may be more substantial and negative than those generated by the gravity model simulations. The empirical gravity model estimated that for both bananas and tart cherries, the trade-reducing effects of MRL divergence would be greater for trade in the individual crops than for the overall crop groupings they are part of. Similarly, the empirical gravity model estimated that greater MRL stringency would have trade-increasing effects for the overall tropical crop grouping, but negative effects for bananas and no clear systematic relationship with tart cherry trade.[482] Therefore, MRL reductions in an important export market may have more substantial direct impacts on Costa Rican banana and U.S. tart cherry exports to the EU than those captured in the gravity model results for the broader crop groupings.

[480] The rationale for analyzing 90 percent reductions is described in chapter 3.
[481] The simulation gravity model did not generate results that are specific to Costa Rica. Simulated price effects for Colombian tropical fruit were used as proxies to analyze the Costa Rican banana industry's supply response. Results were consistent with most non-EU tropical fruit producers' price effects (price increases ranged from 0.03 to 0.33 percent for 12 out of 16 non-EU producing countries). Colombia is a reasonable proxy for Costa Rica in this context, as both countries have similar MRLs for two key tropical fruit exports—bananas and green coffee—and are major exporters of tropical fruit to the EU. However, there are some major differences between these countries' tropical fruit industries: for example, although both countries are major exporters of bananas, Colombia is far more concentrated in green coffee exports, while Costa Rica has substantial pineapple exports. Another difference is that Colombia faces less intense pest pressures than Costa Rica and therefore may not face the same effects when confronted with an MRL change in its key export market, as described in volume 1, chapter 5. Despite these differences, the gravity model simulation results are based on globally established MRL heterogeneity and stringency indexes for all tropical fruit. Therefore, an individual country's concentration within a specific tropical fruit crop or its relative sensitivity to pest pressure may not impact its MRL indexes for tropical fruit overall nor the estimated effects of the change on that broad crop category. The use of a proxy country's results as a substitute for farm gate price effects in Costa Rica adds an additional assumption to the use of these price inputs. Volume 1, 227–28, 230; BCI, "Colombia Pesticide MRLs Market Information Report," June 2020; BCI, Pesticide MRLs database (accessed October 6, 2020); IHS Markit, Global Trade Atlas database (accessed October 6, 2020).
[482] For tropical fruit, the estimate for MRL divergence was −0.252 (standard error of 0.039) and MRL stringency was −0.260 (standard error of 0.075). For bananas, one of several crops included in the tropical fruit crop grouping, the estimate for MRL divergence was −1.143 (standard error of 0.166) and MRL stringency was 0.499 (standard error of 0.204). For temperate fruit, the estimate for MRL divergence was −0.076 (standard error of 0.042) and MRL stringency was 0.125 (standard error of 0.034). For tart cherries, which is in this crop grouping, the estimate for MRL divergence was −0.578 (standard error of 0.177) and MRL stringency was −0.173 (standard error of 0.681).

In addition, the more modest, and in many cases positive, price impacts generated by the gravity model simulations depend to a large extent on agricultural industries' ability to adjust to policy impacts, including shifting between substitute markets. However, this may not be possible for certain industries that rely heavily on the market implementing these policy changes. Costa Rica exports the vast majority of the bananas that it produces; its exports to the European Union accounted for over half of its total exports in 2019.[483] As described in chapter 2, the U.S. tart cherry industry relies on a small group of high-income markets, like the EU, to generate export revenue.[484] The EU is the main U.S. export destination for frozen tart cherries. Therefore, if a reduction in EU MRLs results in a substantial reduction in an industry's exports to the EU, with limited alternative options for diverting those exports to other markets, the price-reducing effect of these policy changes is likely to be more severe.[485] Smaller alternative markets may not be able to fully absorb the exports previously destined for the EU at existing price levels, which will cause prices to fall. Such effects would be greater if other exporting countries are similarly impacted, which would result in greater global competition for the non-EU global market.[486]

In order to approximate the supply response effects of a more substantial price reduction caused by an MRL reduction in an important export market, this analysis also incorporates a uniform 5 percent price reduction in addition to the price impacts generated by the gravity model simulations. A price reduction of 5 percent was not generated by a model, but instead was considered to be a reasonable illustrative price shock that could occur when (1) exporters rely heavily on a foreign market for sales; and (2) that foreign market imposes a highly restrictive measure, reducing market access. Despite the substantial size of this price reduction relative to gravity model results,[487] this estimated impact is conservative

483 Volume 1, 219, 221; IHS Markit, Global Trade Atlas database (accessed August 13, 2020).
484 Tart cherries are subject to a federal marketing order that allows volume controls. Marketing order authorities may require cherries to enter a reserve pool in times of heavy cherry supplies. Cherries that enter the reserve may be used in diversion programs, be exported, or be stored in case of a short crop in the future. See "Tart Cherries Grown in the States of Michigan, et al.; Free and Restricted Percentages for the 2018–19 Crop Year and Revision of Grower Diversion Requirement for Tart Cherries," 84 Fed. Reg. 53003, October 4, 2019.
485 For example, the simulation gravity model generated a farm gate price effect of −0.53 percent for Argentina. Argentina exports a greater proportion of its total shipments to the EU than Colombia does. Argentina was not used as a proxy country because its overall trade in tropical fruit was relatively small compared to that of Costa Rica or Colombia. However, the fact that Argentina's simulated farm gate price effect for tropical fruit, caused by the EU MRL reduction, was more substantial and negative than for most other non-EU exporters supports the conclusion that trade-reducing importer MRL reductions can have more substantial negative effects on countries that rely heavily on those markets.
486 However, as discussed in greater detail below in the description of this approach's limitations, adverse price effects may be mitigated over time as farmers find ways of adjusting production to meet EU standards or reduce supply in response to lower prices.
487 A price reduction of 5 percent is over twice the level of the most substantial price reduction generated in the three gravity model simulations for non-EU exporters (Turkey, tropical fruit).

within the context of certain historical events involving similar trade-impeding MRLs and border measures in key export markets.[488]

The extent to which the agricultural industries respond to changes in price is dependent on the price elasticity of supply for each industry, which refers to the percentage change in output resulting from a 1 percent increase in price. Price elasticities of supply in agricultural industries are affected by a variety of factors—such as the growing conditions for specific products, farmers' ability to produce alternative crops, and agricultural policies and support networks—and may even vary considerably across crops.[489] Both industries likely have relatively low supply responsiveness to changes in prices due to the perennial nature of these crops and the substantial fixed costs associated with production. The Costa Rican banana industry can adjust its output over the medium term by reducing replantings of banana "suckers" (lateral shoots that form the basis of banana plant reproduction).[490] In this analysis, it is assumed that Costa Rican banana production responds to a 1 percent increase in price by increasing output by 0.95 percent.[491] U.S. cherry producers are more limited in their supply response due to the long productive lives of fruit-bearing cherry trees.[492] This analysis uses the assumption that U.S. tart cherry production responds to a 1 percent increase in price by increasing output by 0.48 percent.[493]

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[488] In an extreme example directly relevant to MRLs, when lower MRLs result in compliance issues such that fresh produce is stopped at the border (and either rerouted or destroyed), price declines can be 50 percent or greater. MRLs volume 1, 240–41. In cases where a severe import restriction forces trade to be diverted elsewhere, price declines can be less severe but still substantial. For example, in 2018, the average price of U.S.-produced chickpeas decreased by 28 percent largely due to substantial tariffs imposed by the government of India, a major export destination for U.S. chickpeas. FAO, FAOSTAT database (accessed August 12, 2020); Parr, Bond, and Minor, "Vegetables and Pulses Outlook," May 6, 2019. Looking specifically at the tart cherries market in the United States, a study by Miller et al. estimated that inelastic demand and supply conditions for tart cherries would likely result in substantial price changes in cases where additional supply is added to the domestic market, which could be the case if foreign exports unexpectedly decline in response to lower prices. Miller et al., "Optimal Supply Rules in the Tart Cherry Industry," April 2012, 1.

[489] For example, an FAO study on global banana production estimated that the banana export supply elasticities for Ecuador, Costa Rica, and Colombia were between 0.27 and 0.50 between 1985 and 2000, while supply elasticities for other banana producers were at or near zero. Arias et al., *The World Banana Economy, 1985–2002*, 2003.

[490] Vézina, "Sucker," 2017.

[491] This elasticity is derived from the average of two figures: an estimate of banana export supply elasticity of 0.5 for Costa Rica from 1985 to 2000, produced by FAO, and an estimate of banana supply elasticity of 1.4 for Caribbean countries, produced by Institute for Agriculture and Trade Policy (IATP), National Economic Research Associates (NERA), and Oxford Policy Management. This figure is also consistent with medium-term elasticity estimates for banana production in Australia produced by the Australian Bureau of Agricultural and Resource Economics (ABARE). Arias et al., *The World Banana Economy, 1985–2002*, 2003; NERA Economic Consulting and Oxford Policy Management, *Addressing the Impact of Preference Erosion in Bananas*, 2004; Government of Australia, ABARE, "Approximating Supply Response of a Commodity with Limited Input Data," February 2005.

[492] Miller et al., "Optimal Supply Rules in the Tart Cherry Industry," April 2012, 1.

[493] This elasticity is derived from the average of two figures: a supply elasticity of 0.2 used by Busdieker for apple production (another tree fruit), and a supply elasticity of 0.75 used by Jetter, Chalfant, and Sumner for perennial crops. Busdieker, "Welfare Effects of New Fire Blight Control Methods," 2011; Jetter, Chalfant, and Sumner, "An Analysis of the Costs and Benefits," April 2004.

These elasticities are consistent with a range of price elasticities of supply for a variety of agricultural products from literature.[494]

Limitations of the Supply Response Analysis

This analysis has some limitations. The price effects used as inputs in this analysis are exogenously defined based on an assumption that these are price-taking industries—they react to, but do not exert pressure on, price levels. Therefore, the analysis does not incorporate the effects on prices that may occur as a result of changes in output. For example, if an industry's supply is reduced over time in response to a reduction in price, there is no mitigation of that price decrease resulting from the reduction in supply. Because these are relatively small industries competing in a far larger global market, exogenously derived price inputs are reasonable. But there would likely be some adjustment in farm gate prices caused by the supply responses of these industries that is not captured.[495] A related limitation is that the gravity model results, which form the basis for the first set of price shocks used in the supply response analysis, may not fully represent price effects over a sustained period of time, given that national production is fixed in the model.

The supply response analysis is also limited to the impacts on agricultural production associated with changes in prices caused by MRL actions in foreign export markets. This analysis does not attempt to place these effects within the context of supply variations caused by weather, direct trade actions, currency fluctuations, or any other external effects. The analysis also does not capture additional supply impacts associated with changing agricultural production practices that may result from changes in pesticide applications stemming from global MRL policy changes, such as yield losses and increased costs associated with alternative pesticide use. These changes are captured implicitly in the gravity modeling analysis of chapter 3 (to the extent changes in production are reflected in changes in trade volume and prices), and explicitly in the farm income statement analysis described later in this chapter.[496]

Results and Analysis

For the first set of price shocks, this analysis relies on the price changes found by the gravity model in response to a 90 percent reduction in EU MRLs. As reviewed above, those price changes were relatively modest, and changes in output based on these price shocks are projected to be even more limited. The 0.20 percent increase in Costa Rican banana farm gate prices would result in a 0.19 percent increase in Costa Rican output, or 4,805 metric tons (mt) based on 2018 production data. The 0.17 percent

[494] Several studies covering a range of other fruit and vegetable products found, or used, price elasticities of supply between 0.40 and 1.25. Choi, "Evaluation of Compensation Measures," October 1, 2009; Jetter, Chalfant, and Sumner, "An Analysis of the Costs and Benefits," April 2004, 22; Adiyoga, "Costs and Benefits of Transgenic Late Blight Resistant Potatoes," 2009; Yorobe, Y.M. "Costs and Benefits of Bioengineered Papaya," 2009.
[495] The Costa Rican banana industry accounted for about 2 percent of global banana production in 2018. The U.S. tart cherry industry accounted for approximately 8.9 percent of global tart cherry production in 2018. FAO, 2018 crop production data from FAOSTAT database (accessed August 30, 2020).
[496] Yield effects associated with changes in pesticide application are implicitly captured by the empirical and simulation gravity model estimation results, which show the trade impacts of changes in MRLs in countries' export destinations. Yield impacts are also used as shocks to the farm income statement analysis later in this chapter.

decrease in U.S. tart cherry farm gate prices would result in a 0.08 percent decrease (110 mt) in U.S. tart cherry output (see table 4.2).

For the second set of price shocks, price changes would be more substantial and negative, reflecting an expectation that a substantial MRL decrease or an MRL removal in a key export destination market would cause more substantial direct trade-reducing effects for agricultural producers and/or would be accompanied by fewer alternative export destinations, causing a price decline of 5 percent. At a 5 percent decline in prices, Costa Rican banana production would fall by 4.75 percent (120,117 mt) and U.S. tart cherry production would fall by 2.40 percent (3,247 mt).

Table 4.2 Supply response analysis

Price shock description	Baseline production (mt)	Price change (percent)	Production change Percent	Production change mt	New production (mt)
Bananas (Costa Rica)					
Price shock 1: Moderate price impact derived from gravity model results	2,528,788	0.20	0.19	4,805	2,533,593
Price shock 2: Major price impact (MRL changes reduce trade with key export destination)	2,528,788	-5.00	-4.75	-120,117	2,408,671
Tart cherries (United States)					
Price shock 1: Moderate price impact derived from gravity model results	135,310	-0.17	-0.08	-110	135,200
Price shock 2: Major price impact (MRL changes reduce trade with key export destination)	135,310	-5.00	-2.40	-3,247	132,063

Source: USITC estimates; FAO, 2018 crop production data from FAOSTAT database (accessed August 12, 2020).

Therefore, it is likely that the U.S. tart cherry industry would experience modest reductions in production in response to lower prices resulting from reduced MRLs in a major export market like the EU. The Costa Rican banana industry could experience a greater range of effects from such a change in MRLs. Slight increases in Costa Rican banana production in response to price increases would be expected if the global banana industry adjusts with minimal disruption in prices, as depicted in the gravity model results for tropical fruit. Alternatively, a more substantial decrease in production in response to reduced prices would be expected if Costa Rican banana producers find fewer alternative markets in response to a major EU MRL reduction.

These results collectively suggest that production impacts of MRLs are likely to be directionally consistent with price effects, albeit more modest. As discussed above with respect to the limitations of this analysis, there is also an expectation that the price effects used as inputs in this analysis would be reduced further by the supply responses of these industries. These price-mitigating effects are not captured here and would likely reduce the extent of supply impacts that occur over the long term, as the market would reach equilibrium at quantity and price levels that are closer to baseline levels. However, as the production impacts of MRLs caused by yield loss or higher costs associated with alternative pesticide use, for example, are not captured by the supply response analysis, these costs could have more substantial production-reducing effects than the analysis here based on price changes alone shows. As described below, the impact of MRL changes can have a greater impact on farms' production if it causes them to change their pesticide inputs, which may influence farm yields.

Farm Income Statement Analysis: Economic Effects at the Farm Level

As discussed in volume 1, MRL reductions in certain markets (including through removal of MRLs and application of low default levels) may have a variety of effects on individual farms producing crops for export to those markets. These effects may include additional compliance costs related to reduced or changed pesticide use; yield losses; and/or the need to find new markets for crops that are no longer in compliance with import market MRLs. Nonetheless, certain farms may experience positive effects when importers reduce MRLs: farms that are able to comply with stricter MRLs may experience a price increase due to reductions in competition within that market that may offset increased compliance costs. In some cases, there has also been evidence that trade volumes increase when importer MRLs decrease. A farm income statement analysis is used in order to understand the practical impacts of MRL changes on individual farms' operations, particularly farm income.

Farm Income Statement Analysis Methodology

The farm income statement analysis uses techniques derived from enterprise budgeting in order to assess the multidimensional impacts of MRL reduction and removal on hypothetical farms producing specific crops in exporting countries. Enterprise budgeting is an accounting method used by agricultural extension practitioners and farmers to assess the financial impacts of farm business decisions.[497] It is therefore a useful tool for illustrating the financial tradeoffs associated with the practical decisions that farmers have to make when confronted with potential trade, production, price, and income effects of MRL changes in major export markets.

The other economic analyses of this report analyze the impacts of MRL changes on national or global-level industries, and therefore produce results that capture the effects of these policies on the many diverse farms that comprise these industries. For individual farms, the effects of MRL changes in export markets can be far more substantial than these aggregate effects, as described in chapter 2 of this volume and the case study chapter in volume 1 of this report. The farm income statement analysis uses these effects described in the case studies and assesses the impact that these would have on individual farms.

For each simulation—bananas produced in Costa Rica and tart cherries produced in the United States—a "typical" farm is described that represents the type of agricultural operations that exist within that country's industry. Information necessary to construct the typical farm is based on case studies, staff field work, data from the Food and Agriculture Organization of the United Nations (FAO), and other literature. Using this information, a simplified farm income statement is developed that accounts for all costs and revenues for a single year. Various scenarios are then used to assess the farm's options for

[497] Penn State Extension, "Budgeting for Agricultural Decision Making," March 29, 2019; Chase, "Using Enterprise Budgets to Make Decisions," June 2006.

responding to reductions or removals of MRLs in a major export destination market. Based on information derived from case studies, quantitative shocks are applied to the farm's income statement based on changes in trade, prices, production, and income that would be expected under these scenarios. The analysis examines the impacts of these changes on the farm income statement and assesses the tradeoffs faced by the farmer when responding to changes in MRLs. More detail with respect to these methodologies is provided within the description of the individual farms, scenarios considered, and results presented below as well as in appendix G.

Farm Income Statement Analysis Limitations

One limitation of the farm income statement analysis is that, in attempting to construct an income statement for a typical farm within these industries, it does not depict any actual individual farm's income statement. Income statements were developed using information drawn from diverse sources that likely represent heterogeneous entities operating across these industries. In some cases, information used to construct income statements was approximated based on best estimates. Therefore, these income statements form a reasonable presentation of farms' trade, prices, production, and income; however, they should not be considered wholly representative of farms operating in these industries. Except in cases where confidential business information would be revealed, the data sources used in this analysis are documented below and in appendix G.

Another limitation concerns the scenarios chosen within these analyses and the quantitative shocks that are imposed on line items within income statements to demonstrate the effects of MRLs. Because these scenarios and shocks are derived from case studies, they represent the experiences and expectations of the businesses and industries that provided information in those case studies and associated staff fieldwork. In some instances, quantitative shocks were approximated based on qualitative descriptions. Therefore, these scenarios and shocks may not capture the full diversity of possible MRL effects, or extent of effects, on individual farms.

Results and Analysis

Siquirres Banana Farm—Costa Rica

Bananas are a fast-growing tropical crop that face high pest pressures. Mealybugs, scale insects, nematodes, and a fungal disease called black sigatoka are the main pests threatening bananas in Costa Rica and throughout the Americas. As described in the first volume of this report, because of these high pest pressures and short harvest intervals, meeting low export market MRLs is challenging. Most Costa Rican bananas are produced on large farms (over 250 acres) for export to the United States and the EU rather than for the domestic market.[498]

The typical banana farm ("Siquirres Banana Farm") in this scenario produces conventionally grown bananas on 900 hectares for export.[499] This hypothetical operation is part of a large international

[498] USITC, *Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels, Vol. 1* ("volume 1"), June 2020, 221.

[499] As an example of how large individual companies' operations can be, Dole, a major banana grower in Costa Rica, owned 21,800 acres producing bananas in Costa Rica in 2012. Dole Food Company, "Form 10-K," 2013.

company, and is based in the Siquirres region on the Caribbean side of Costa Rica near the Port of Limón. The Siquirres Banana Farm has an annual yield of 49.2 mt/hectare consistent with that region's average.[500] This equates to annual farm production of 44,280 mt, for which it receives an average price of $453/mt and revenue of $20.1 million.[501] Its variable costs (labor and other supplies) total $11,217/hectare, equivalent to $228/mt at baseline production levels.[502] Total variable costs are $10.1million, while fixed costs (such as administrative costs and machinery) associated with growing operations equate to $3.2 million.[503] The farm realizes a net income of $6.7 million, or 33.6 percent.

Based on the income statement of the Siquirres Banana Farm, this analysis simulates the reduction of MRLs in the EU, the most important market for Costa Rican banana exports, based on information provided in case study analysis and research in volume 1.[504] Costa Rican banana producers primarily produce to meet EU MRLs, so it is assumed that European MRL reductions essentially require Costa Rican producers to also produce to those MRLs.[505] In addition, the EU has recently reduced certain MRLs for critical pesticides used in banana production, including buprofezin, chlorpyrifos, and chlorothalonil, to 0.01 ppm. The EU did not renew its approval of chlorpyrifos and chlorothalonil, and these MRLs defaulted to the limit of determination in early 2020. EU approval for mancozeb expires in January 2021, and banana industry representatives are already concerned that it may not be renewed (see chapter 4 of volume 1 for more details).[506] Therefore, the scenarios used in this simulation involve the effects of these MRL reductions as well as possible additional reductions of MRLs that are necessary for the treatment of nematodes (fluopyram), mealybugs and scale insects (the insecticides bifenthrin and pyriproxyfen), and the black sigatoka fungus (mancozeb) that are the remaining primary pest management options for Costa Rican growers.[507]

Although the Siquirres Banana Farm starts from a baseline of significant profitability, its options are limited in response to a major reduction or removal of MRLs in an importer market such as the EU. Because of the regional nature of the global banana market, where Latin American countries largely focus exports to Europe and the United States, it is challenging for Latin American banana producers to divert exports from one of their largest markets to other destinations.[508] Although it may have an incentive to sell into markets where MRLs are comparably higher, the Siquirres Banana Farm's large size and vertical integration within a broader international company may actually disadvantage its ability to shift sales away from the EU. As described in volume 1, vertically integrated banana-producing operations in Costa Rica do not segregate by export destination, and they produce based on the MRL

[500] Government of Costa Rica, MAG, SEPSA, *Boletín Estadístico Agropecuario* (Bulletin of Agricultural Statistics), April 2020, 30.
[501] Based on FAO, 2018 annual average producer price from FAOSTAT database (accessed August 7, 2020).
[502] Cost per hectare is derived from Government of Costa Rica. Ministry of Agriculture and Livestock, (SEPSA), "Modelo de Costos de Producción, Plátano" (production cost model, bananas), 2019.
[503] Cost per hectare is derived from Government of Costa Rica. Ministry of Agriculture and Livestock, (SEPSA), "Modelo de Costos de Producción, Plátano" (production cost model, bananas), 2019.
[504] Volume 1, 219.
[505] Volume 1, 221.
[506] Volume 1, 224.
[507] Volume 1, 223–229.
[508] Volume 1, 219–220. This is particularly true given that the EU market prefers smaller bananas than other markets do, which has caused Costa Rican producers to produce bananas to conform to that market preference. Selling these smaller bananas into alternate markets would result in lower prices. Volume 1, 230.

requirements of the most restrictive export destination.[509] Even if the Siquirres Banana Farm were to attempt to produce to less stringent MRLs and sell bananas to other markets, such a decision would have to be made for all of its production due to the infeasibility of segregating production based on pesticide use.[510] Therefore, any production decision to shift away from EU MRLs would have to be based on an assumption that the entirety of the farm's large banana crop would be able to find buyers outside the EU.

For these reasons, it would be impractical for the farm to abandon EU MRLs, and it is assumed that the farm would continue to monitor and adapt its agricultural production practices to ensure that residues for specific pesticides remain consistent with EU requirements. Despite the challenges posed by maintaining these standards of production, the farm would continue to have access to all global markets for bananas. For this reason, the income statement does not differentiate between shipment destinations: it is assumed that the farm would continue to participate in the EU as well as its other markets.

Because the Siquirres Banana Farm would maintain its ability to participate in all global export markets and adjust to price changes, all of the scenarios analyzed here further assume that there would be no change in the Siquirres Banana Farm's farm gate prices. As described above in the supply response analysis, it is possible that the trade-reducing impacts of MRL stringency and divergence on trade in bananas might cause banana prices to decline. Such a price reduction might occur because certain competitors (such as independent producers and third-country competitors) that cannot comply with EU MRLs would cease sales to that market and would push down national farm gate prices overall if they divert trade away from the EU and cause supply increases in other markets.

However, because the Siquirres Banana Farm's exports would be unlikely to be substantially diverted away from the EU (where prices are unlikely to decrease or may even increase), such countrywide farm gate price decreases would be mitigated for this producer.[511] Although there may be volatility elsewhere in the global banana market or for the Costa Rican banana industry as a whole, the Siquirres Banana Farm's position in multiple markets and its commitment to produce to the lowest MRL level likely would afford it greater price stability overall. Therefore, the farm's overall prices would be unlikely to change substantially, consistent with the results of the simulation gravity model, where exporters would be similarly able to adjust in response to MRL effects on bilateral trade flows.[512]

Since the banana farm must continue to produce to EU MRLs, it would face two alternatives when confronted with reductions in EU MRLs. First, the farm could switch production practices to use other pest control measures to the extent possible, such as trying alternative pesticides. This decision would affect all farm operations, as pest pressures, close proximity to other farms, and climatic conditions prevent Costa Rican farmers from segregating production or shifting to organic production in response

[509] Volume 1, 221.
[510] Volume 1, 229.
[511] Further reducing the likelihood of trade diversion to lower-priced destinations in response to a shift in the EU MRL, the Costa Rican government raised the minimum price per box of bananas for export starting January 1, 2020, to $8.36 per 18.14 kg box exported, or about $461/mt. Government of Costa Rica, Executive Decree No. 42112-MEIC-MAG-COMEX. This price is higher than the farm gate price of $453/mt used in this simulation.
[512] As described above, the simulation gravity model generated relatively stable price effects for most non-EU exporters of tropical fruit, based in part on exporters' ability to adjust in response to bilateral trade impacts of changes in MRL stringency and heterogeneity.

to low MRLs. However, given the intensity and diversity of pest pressures that Costa Rican farmers face, increased pest resistance to existing pesticides, and lack of alternative pesticides, it is likely that the decision to continue to produce to EU MRL levels would result in yield losses. As described in volume 1 of this report, banana producers in Costa Rica primarily described the effects of low MRLs or MRL removals in terms of their concerns over yield losses, particularly when MRLs in key exports are lowered or removed before additional alternatives can be developed.[513] Such yield losses could include losses to nematodes (41 percent yield loss if left untreated), mealybugs and scale insects (27.8 percent yield loss, combining the impact of both pests), and black sigatoka fungus (6.3 percent, assuming increased farm costs of 3.5 percent due to alternative treatment needed).[514] Alternatively, the banana farm may decide to cease banana production. For these simulations, it is assumed that the banana farm would continue to produce in the short run as long as its revenues exceed its variable costs, although it will ultimately cease production in the long run if its operating incomes are negative.

Two scenarios were considered within the analysis of the Siquirres Banana Farm's income statement. The first scenario represents the type of worst-case scenario that could occur if many crop protection products were made unavailable to banana growers over a short period of time. Under this scenario, applied for combined removals of nematocides and insecticides, yield losses would increase to the full level expected when nematode and insect pressures are left untreated. The second scenario, focusing on fungicide removal, represents the removal of individual pesticides where alternatives are available. These more iterative removals—associated with more muted yield loss and cost effects—are more realistic scenarios facing banana growers over short periods of time. However, overuse of smaller numbers of alternative pesticides can result in increased pest resistance over time that can ultimately lead to yield losses that are more similar to those seen in scenario 1.[515]

Changes to yield and variable costs are directly applied to these variables in both scenarios. Within this analysis, farm size, producer prices, and fixed costs are assumed to remain fixed at baseline levels across all scenarios. All other variables change in response to yield and cost effects. For more information on the relationship between these indicators, see appendix G.

Scenario 1: Removal of MRLs for all key insecticides and nematocides used by Costa Rican producers (yield loss of 57.4 percent). Under this scenario, yield would be reduced by 57.4 percent, which is the compounded effect of losses to nematodes, mealybugs, and scale insects. Variable costs due to lower pesticide application labor costs and lower cost of pesticides would be reduced by $1.8 million.

Scenario 2: Removal of MRL for fungicide mancozeb, with alternative treatment applied (would yield a loss of 6.3percent and a 3.5 percent increase in variable farm costs).

[513] Volume 1, 219-230.
[514] Derived from information provided by industry representative, interview by USITC staff, San José, Costa Rica, December 5, 2019; Kynetec, *Report: Value of Mancozeb If EU MRLs Are Revoked*, October 18, 2019, 18–19.
[515] The relationship between these types of worst-case and more iterative scenarios is described in greater detail in volume 1. Volume 1, 228–30.

Table 4.3 Estimated effects of missing and low EU MRLs on the Siquirres Banana Farm's income statement

Indicator	Baseline	Scenario 1	Scenario 2
Farm size (ha)	900	900	900
Yield (MT/ha)	49.2	21.0	46.1
Production (mt)	44,280	18,863	41,490
Shipments (mt)	44,280	18,863	41,490
Producer price ($/mt)	453.00	453.00	453.00
Unit costs ($/mt)			
Variable costs	228	438	252
Fixed costs	73	171	78
Total costs	301	609	330
Revenue ($)	20,058,840	8,545,066	18,795,133
Costs ($)			
Variable costs	10,095,712	8,267,301	10,449,062
Fixed costs	3,228,038	3,228,038	3,228,038
Total costs	13,323,749	11,495,338	13,677,099
Operating income ($)	6,735,091	-2,950,272	5,118,034
Operating income margin (percent)	33.6	-34.5	27.2

Source: USITC estimates; Government of Costa Rica, MAG, SEPSA, "Boletín Estadístico Agropecuario" (bulletin of agricultural statistics), April 2020, 30; FAOSTAT database (accessed August 12, 2020); Government of Costa Rica, MAG, SEPSA, "Modelo de Costos de Producción, Plátano" (production cost model, bananas), 2019; volume 1, 219–30. For more detail on the sources for these data, see appendix G.

This analysis shows the substantial impacts that MRL removals could have on a Costa Rican banana producer's yields. In Scenario 1, severe yield losses associated with uncontrolled insect and nematode pest pressures would result in a previously profitable operation becoming deeply unprofitable. Revenues would exceed variable costs, so the farm would continue to have an incentive to produce as long as this remains the case, but any long-term investment in these operations would likely be limited.

Scenario 2 shows the impact of an EU removal of one MRL, which would result in the Siquirres Banana Farm discontinuing use of that pesticide and attempting to maintain production using an alternative pesticide. In this circumstance, the farm would be partially successful at reducing yield loss associated with the loss of mancozeb by incurring greater variable costs associated with a less effective pesticide. Therefore, its total costs would increase, but its costs per metric ton would not increase as much as in scenario 1. Although the farm would remain profitable, the combined increases in costs and decreases in output would nonetheless result in a substantial decline in profitability.

Together, the two scenarios demonstrate concerns raised by Costa Rican industry representatives, who assert that, with recent and ongoing EU removals of MRLs for pesticides that are important to banana production, the backbone of IPM for this industry could be seriously undermined.[516] Scenario 2 illustrates what might occur as a marginal result of one of these policy changes after the industry is able to adjust to changes by implementing new production practices. However, this type of result may not be sustainable in the long run, as increased pest resistance to a more limited number of available pesticides, in addition to increased pest pressure due to a warmer climate, may hamper the effectiveness of alternative pesticides. Therefore, results similar to that of scenario 1 which

[516] Volume 1, 229.

demonstrates the absence of crop protection options for managing insect and nematode pest pressure, represent the longer-term concern for Costa Rican banana producers.[517]

Michigan Tart Cherry Farm—United States

U.S. tart cherries are produced in orchards that may be hundreds of acres in size.[518] The large majority of tart cherries produced in the United States are further processed into frozen or dried cherries, juices, or other products.[519] Processing and selling of these further processed products may be performed by grower-owned companies, agricultural cooperatives, or independent companies. Most tart cherries are sold for consumption in the United States, but these sales are capped by a marketing order that attempts to stabilize sales and price levels in the United States over time.[520] Therefore, exports are an important source of income for U.S. tart cherry producers if they are able to meet the MRL requirements of those export destination markets. The U.S. tart cherry industry is described in greater detail in the tart cherry case study in chapter 2 of this report.

Based on these characteristics, the typical tart cherry farm ("Michigan Tart Cherry Farm") is a family-owned farm in Michigan, the main tart cherry-producing region in the United States. This hypothetical farm has 100 acres and has an annual yield that varies significantly from year to year, with yield in the baseline year of 8,000 pounds of tart cherries per acre (totaling 800,000 pounds in annual production).[521] This farm is part of a cooperative that seeks to strategically target specific markets, including export markets, in order to maximize the prices that farmers are able to get for their produce. To achieve this, cooperative "handlers" work with their growers to determine which pesticides to use to manage shifts in pest pressures, global prices, and MRL regulations.

In addition, this cooperative organizes toll processing in order to sell tart cherries in a processed or semi-processed form in order to take advantage of higher-value-added markets.[522] Growers incur the upfront costs for toll production and subtract these costs from sales of processed products. Farm gate prices for the grower are therefore equivalent to all revenues from sales of processed products minus processing costs.

Under the baseline scenario, the Michigan Tart Cherry Farm is able to sell to all global markets when producing based on U.S. MRLs. Its variable costs (including inputs, labor, maintenance) total $158,200.

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[517] The relationship between these types of worst-case and more iterative scenarios is described in greater detail in volume 1. Volume 1, 228-230.

[518] For example, King Orchards in Northern Michigan reportedly grows tart cherries on over 140 acres. King Orchards, "Visiting King Orchards in Northern Michigan" (accessed August 13, 2020).

[519] Many of the underlying facts and data provided in this farm income statement analysis are derived from the case study on tart cherries described in chapter 2.

[520] "Tart Cherries Grown in the States of Michigan, et al.; Free and Restricted Percentages for the 2018–19 Crop Year and Revision of Grower Diversion Requirement for Tart Cherries," 84 Fed. Reg. 53003, October 4, 2019.

[521] Penn State Extension, "Mature Tart Cherry Production Orchard Budget," 2020.

[522] Toll processing refers to a production supply chain that involves an original producer of a raw material using a third-party company to perform processing operations using that material without the original producer transferring ownership of the product.

Its fixed costs (including annualized costs for equipment and land) total $30,602 for the full farm.[523] Its cooperative is able to find an EU buyer for 10 percent of all production at a price of $0.84 per pound for individually quick frozen (IQF) cherries sold in bulk. After toll processing, $0.39 per pound is returned to the farm from this sale, which is considerably higher than the prevailing domestic price of $0.22 per pound.[524] Although 90 percent of the Michigan Tart Cherry Farm's sales in the United States are sold at a loss due to the challenging domestic pricing conditions of this baseline year, the higher prices received in the sale to the European Union substantially mitigate those losses. The farm is therefore able to break even with an operating income margin of 0.4 percent.

The alternative scenarios discussed in this analysis are based on the current status of active substances used in the United States to manage challenging and shifting pest pressures associated with SWD. In all scenarios the European Union does not have an MRL for fenpropathrin, an important active ingredient used in insecticides used to manage SWD, but does have MRLs for alternative pesticides. The Michigan Tart Cherry Farm essentially would face three choices in response to a lack of EU MRL for fenpropathrin, which differ from the baseline scenario in which the farm would be able to export to the EU without facing any additional obstacles: change production practices to meet EU standards; risk noncompliance with the new MRL standard; or abandon the EU market.

Together, scenarios 1–3 demonstrate how foreign MRLs impacting even a relatively small share of a farm's total shipments could have substantial income-decreasing effects if they were to force a farm to change production practices and increase costs, risk noncompliance and severe losses, or forego export opportunities. In certain cases, however, a restrictive foreign MRL may present opportunities for certain exporters who are able to shift their production practices, particularly when they are uniquely positioned to do so. Scenario 4 simulates a situation in which the U.S. tart cherry industry may be in a position of competitive advantage relative to other exporting producers and may experience a benefit from exporting to the restrictive EU market. Table 4.4 illustrates the effects of missing and low EU MRLs on U.S. tart cherry producers for each of these scenarios.

Changes to variable costs and the proportion of shipments that go to various export markets are directly applied variables in each of the scenarios. Within this analysis, farm size and fixed costs are assumed to remain fixed at baseline levels across all scenarios. In addition, yield is held constant across all of these scenarios notwithstanding changes in pesticide use, as there is no indication that alternative pesticide use (despite being more expensive) reduces yields. While prices received in the EU, non-EU, and domestic markets each remain constant, overall prices received by the farm fluctuate based on the

[523] Variable and fixed costs are derived from per acre costs provided within a tart cherry production orchard budget, multiplied by 100 acres, and adding in a $500 testing fee applied to total variable costs. Industry representative, telephone interview by USITC staff, July 8, 2020; Penn State Extension, "Mature Tart Cherry Production Orchard Budget," 2020.

[524] Based on information from the case studies, EU prices for IQF cherries for this exercise are $0.84/pound, while non-EU prices for IQF cherries are $0.14/pound. U.S. farm gate prices for unprocessed tart cherries are $0.22/pound. Within the case study, farmers incurred prepaid processing costs necessary to produce IQF cherries from unprocessed cherries. This prepaid processing cost is unknown, but given the high added value associated with processing and the substantial difference between the EU price for IQF cherries and the U.S. farm gate price for unprocessed cherries, it was likely a substantial portion of the overall price agreed upon with the EU buyer. As an assumption, the farm income statement analysis uses an IQF prepaid processing charge of $0.45/pound.

proportion of sales made into each channel. All other variables change in response to shipment and cost effects. For more information on the relationship between these indicators, see appendix G.

Scenario 1: The farm would use alternative pesticides to treat SWD and continue to export 10 percent of its shipments to the European Union. Use of alternative pesticides would lead to an increase of variable costs by $13,000.

Scenario 2: The farm would use alternative pesticides to treat SWD but would be forced to divert 10percent of its shipments to another export destination following accidental noncompliance in the European Union. Use of alternative pesticides would lead to an increase of variable costs by $13,000, while storage fees incurred would add an additional $6,000.

Scenario 3: The farm would use fenpropathrin to treat SWD and would sell all produce in the U.S. market. The farm would no longer incur testing fees necessary to export to the EU market and saves $500 in variable costs.

Scenario 4: The farm would use alternative pesticides to treat SWD and would export 50 percent of its shipments to the European Union. Use of alternative pesticides would lead to an increase of variable costs by $13,000.

Table 4.4 Estimated effects of missing and low EU MRLs on the Michigan Tart Cherry Farm's income statement

Indicator	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Farm size (acre)	100	100	100	100	100
Production (pounds)	800,000	800,000	800,000	800,000	800,000
Yield (pounds/acre)	8,000	8,000	8,000	8,000	8,000
Exports (pounds)					
To EU	80,000	80,000	0	0	400,000
To other	0	0	80,000	0	0
Domestic shipments (pounds)	720,000	720,000	720,000	800,000	400,000
Producer price ($/pound)	0.24	0.24	0.17	0.22	0.31
Unit costs ($/pound)					
Variable costs	0.20	0.21	0.22	0.20	0.21
Fixed costs	0.04	0.04	0.04	0.04	0.04
Total costs	0.24	0.25	0.26	0.24	0.25
Revenue ($)	189,600	189,600	133,600	176,000	244,000
Costs ($)					
Variable costs	158,200	171,200	177,200	157,700	171,200
Fixed costs	30,602	30,602	30,602	30,602	30,602
Total costs	188,802	201,802	207,802	188,302	201,802
Operating income ($)	798	-12,202	-74,202	-12,302	42,198
Operating income margin (percent)	0.4	-6.4	-55.5	-7.0	17.3

Source: USITC estimates; PSU, Extension, "Mature Tart Cherry Production Orchard Budget," 2020; chapter 2 of this volume. For more detail on the sources for these data, see appendix G.

Scenario 1: In this scenario, the Michigan Tart Cherry Farm would be advised by its cooperative handler that U.S. pricing conditions are likely to be challenging, and that it should shift its production practices to attempt to meet EU MRLs for tart cherries with the objective of targeting sales to that market. Following this advice, the farm would be able to successfully manage SWD pressure with no loss of yield by using alternative insecticides that have similar U.S. and EU MRLs, but which cost $130 more per acre over the course of the year.[525] If the farm chooses to use this production strategy, it would not know how much of its crop it will sell to the EU, nor would it segregate pesticide exposure and use within its orchard. Therefore, it would apply these production methods for its entire orchard. When its cooperative successfully gains the sale of frozen tart cherries to the EU (as assumed under this scenario), the farm's total revenues would remain the same in this scenario as in the baseline. However, the farm's costs would be considerably higher, and it faces an operating income loss of 6.4percent on all sales.

Scenario 2: The second scenario focuses on a sequence of events, drawn from case study analysis, that demonstrates the potentially severe farm income effects that can occur as a result of inadvertent MRL violations.[526] In this scenario, the farm would use the same production practices as those described in Scenario 1—production practices that it understands would bring it into compliance with EU MRLs. Repeated testing within the United States would confirm that residues are below EU MRLs. However, additional testing in the EU would produce a result that shows residues above the EU MRL. Therefore, the entire shipment would not be delivered to the EU customer, and the contract for the sale would be canceled. The shipment would sit in frozen storage for one month and incur an additional storage fee of $6,000, which would be passed back to the grower. Recognizing that the seller has no options to sell this produce in the EU and is facing destruction of the shipment if not sold, a purchaser in another country would agree to acquire the shipment of frozen tart cherries at a price of $0.14 per pound. Because this sale would be made at a level even below the cost of toll production, the farm would incur substantial losses on this sale, resulting in an overall operating income loss of -55.5 percent.

Scenario 3: This scenario presents an alternative in which the Michigan Tart Cherry Farm adopts an early strategy to avoid selling to the EU and to focus only on domestic sales. In this scenario, the farm would save on all of the additional testing and alternative pesticide costs required to meet EU MRLs. However, in a year when domestic prices are low, the lack of access to high-priced export opportunities such as the IQF sale to the EU would substantially reduce the farm's income. The farm would incur an operating income loss of 7.0percent if it sells only to the relatively low-priced domestic market in this year.

Scenario 4: The last scenario considers a case where MRLs have made the EU market less accessible to most global producers of tart cherries, but where the Michigan Tart Cherry Farm would be able to take advantage of its cooperative's research and knowledge of alternative pesticides to be uniquely positioned to continue to serve this market. In this case, its decision to produce in compliance with EU MRLs (similar to its decision in Scenario 1) would result in it gaining a contract for 50 percent of its total production at the same prices as in the baseline ($0.84 per pound for IQF tart cherries, with $0.39 per pound returning back to the farm). Due to its substantially greater revenue from these sales, its operating income would be 17.3 percent in an otherwise difficult year for U.S. tart cherry growers.

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[525] The assumption used in this analysis that there would be no loss of yield while using alternative is based on information provided by industry representatives who highlighted the increased costs associated with using alternative pesticides rather than yield losses. Industry representative, telephone interview by USITC staff, June 8, 2020; industry representative, telephone interview by USITC staff, July 8, 2020.

[526] Several of the events and data used to produce this scenario are drawn from a case study discussion in chapter 2 that focuses on a customer rejection related to pesticide testing required by the final purchaser, not an MRL violation per se. Nonetheless, the types of costs associated with MRL noncompliance are captured within this information and are therefore used here.

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Appendix A
Request Letter

THE UNITED STATES TRADE REPRESENTATIVE
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON

August 30, 2019

The Honorable David S. Johanson
Chairman
U.S. International Trade Commission
500 E Street, SW
Washington, DC 20436

Dear Chairman Johanson:

I am writing today regarding the Office of the United States Trade Representative's ongoing efforts to address barriers to U.S. agricultural trade exports, specifically sanitary and phytosanitary (SPS) barriers. The Administration seeks to gain a greater understanding of existing and emerging challenges to the current international and country-specific frameworks for pesticide maximum residue levels (MRLs), particularly in major markets, and a better understanding of whether current frameworks provide adequate support for agricultural trade. Farmers worldwide are confronted with numerous challenges affecting their use of plant protection products, including missing and low MRLs, and are increasingly concerned about the lack of adherence to well-established scientific principles in MRL decision-making processes.

Therefore, under authority delegated by the President to the United States Trade Representative and pursuant to section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)), I request that the U.S. International Trade Commission conduct an investigation and prepare a report on the global economic impact of national MRL policies on plant protection products. The report should include, to the extent practicable, information and analysis regarding the economic impact of pesticide MRLs on farmers in countries representing a range of income classifications (e.g., low income, lower middle income, upper middle income, etc.) as well as the United States. To the extent information is available, the report should cover the years 2016-2019, or the latest 3 years for which data are available, but may, where appropriate examine longer-term trends. This report should include the following:

(1) An overview of the role of plant protection products and their MRLs in relation to global production, international trade, and food safety for consumers. Describe the current and expected challenges to global agricultural production, including the impact of evolving pest and diseases pressures in differing regions and climates.

(2) A broad description of the approaches taken in setting national and international MRLs for crops. Describe the risk-based approach to setting MRLs in the context of agricultural trade, including the guidelines and principles of the Codex Alimentarius. Describe the procedures in the Codex Alimentarius for setting pesticide MRLs, including the role of the FAO/WHO Joint Meeting on Pesticide Residues (JMPR) in conducting risk assessments. Compare this risk-based approach to a hazard-based approach. Describe U.S. efforts to advance the use of lower-risk pesticides globally.

(3) A description of how MRLs for plant protection products are developed and administered in major markets for U.S. agricultural exports. Describe the specific regulations, processes, practices, and timelines in these major markets for establishing, modifying, and administering MRLs. Describe specific MRL enforcement practices and processes, including practices and procedures for addressing non-compliant imported plant products. Provide examples of how Codex MRLs are adopted into national legislation or regulation. Identify trade-facilitative practices and processes.

(4) A description of challenges and concerns faced by exporting countries in meeting importing country pesticide MRLs, such as when MRLs are missing or low. Explain the reasons for missing and low MRLs.

(5) Through case studies, describe the costs and effects of MRL compliance and non-compliance for producers in countries representing a range of income classifications, such as uncertainty in planting decisions, segregation of products, crop protection costs, yield implications, storage issues, product losses, and consequences of MRL violations. Include information on costs of adopting new plant protection products or those related to establishing, modifying, or testing for new or existing MRLs in export markets. To the extent possible, include effects on producers in countries with tropical climates where products are subject to high levels of pest and disease pressure.

(6) A review of the economic literature that assesses both qualitatively and quantitatively how missing and low MRLs affect countries representing the range of income classifications, particularly low income countries, with regard to production, exports, farmer income, and prices.

(7) Through case studies, describe the costs and effects of MRL compliance and non-compliance for U.S. producers, such as uncertainty in planting decisions, segregation of products, crop protection costs, yield implications, storage issues, product losses, and consequences of MRL violations. Include information on costs of adopting new plant protection products or those related to establishing, modifying, or testing for new or existing MRLs in export markets. To the extent possible, include effects on U.S. producers of specialty crops.

(8) To the extent possible, quantitatively and qualitatively assess how missing and low MRLs affect production, exports, farmer income, and prices, both on the national level and, to the extent possible, for small and medium size farms.

I request that the Commission prepare this report, "*Global economic impact of missing and low pesticide MRLs*", in two volumes and deliver it according to the dates set forth below:

- Volume 1 by April 30, 2020 covering bullets (1) - (6) above, and
- Volume 2 by October 31, 2020 covering bullets (7) – (8).

It is my intent to make the Commission's report available to the public in its entirety. Therefore, the report should not include any business confidential information.

I appreciate the cooperation and attention of the Commission on this matter.

Sincerely yours,

Robert E. Lighthizer

Appendix B
Federal Register Notices

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concerning subject imports from Canada before a bi-national Panel established pursuant to Article 1904 of the North American Free Trade Agreement. The Panel affirmed in part and remanded in part the Commission's determinations. *In the Matter of Softwood Lumber from Canada: Interim Decision and Order of the Panel,* Secretariat File No. USA–CDA–2018–1903–03 (September 4, 2019). Specifically, the Panel remanded for the Commission to reconsider certain aspects of its analysis and findings concerning the conditions of competition and the volume of subject imports and their price effects.

Participation in the proceeding.—Only those persons who were interested parties that participated in the investigations (*i.e.,* persons listed on the Commission Secretary's service list) and also parties to the appeal may participate in the remand proceedings. Such persons need not make any additional notice of appearances or applications with the Commission to participate in the remand proceedings, unless they are adding new individuals to the list of persons entitled to receive business proprietary information ("BPI") under administrative protective order. BPI referred to during the remand proceedings will be governed, as appropriate, by the administrative protective order issued in the investigations. The Secretary will maintain a service list containing the names and addresses of all persons or their representatives who are parties to the remand proceedings, and the Secretary will maintain a separate list of those authorized to receive BPI under the administrative protective order during the remand proceedings.

Written Submissions.—The Commission is not reopening the record and will not accept the submission of new factual information for the record. The Commission will permit the parties to file comments concerning how the Commission could best comply with the Panel's remand instructions.

The comments must be based solely on the information in the Commission's record. The Commission will reject submissions containing additional factual information or arguments pertaining to issues other than those on which the Panel has remanded this matter. The deadline for filing comments is October 15, 2019. Comments shall be limited to no more than thirty (30) double-spaced and single-sided pages of textual material, inclusive of attachments and exhibits.

Parties are advised to consult with the Commission's Rules of Practice and Procedure, part 201, subparts A through E (19 CFR part 201), and part 207, subpart A (19 CFR part 207) for provisions of general applicability concerning written submissions to the Commission. All written submissions must conform to the provisions of section 201.8 of the Commission's rules; any submissions that contain BPI must also conform with the requirements of sections 201.6, 207.3, and 207.7 of the Commission's rules. The Commission's *Handbook on E-Filing,* available on the Commission's website at *http://edis.usitc.gov,* elaborates upon the Commission's rules with respect to electronic filing.

Additional written submissions to the Commission, including requests pursuant to section 201.12 of the Commission's rules, will not be accepted unless good cause is shown for accepting such submissions or unless the submission is pursuant to a specific request by a Commissioner or Commission staff.

In accordance with sections 201.16(c) and 207.3 of the Commission's rules, each document filed by a party to the investigation must be served on all other parties to the investigation (as identified by either the public or BPI service list), and a certificate of service must be timely filed. The Secretary will not accept a document for filing without a certificate of service.

By order of the Commission.

Issued: September 23, 2019.

Lisa Barton,

Secretary to the Commission.

[FR Doc. 2019–20976 Filed 9–26–19; 8:45 am]

BILLING CODE 7020–02–P

INTERNATIONAL TRADE COMMISSION

[Investigation No. 332–573]

Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels Institution of Investigation and Scheduling of Hearing

AGENCY: United States International Trade Commission.

ACTION: Institution of investigation and scheduling of public hearing.

SUMMARY: Following receipt of a request from the U.S. Trade Representative (USTR) on August 30, 2019, under the Tariff Act of 1930, the U.S. International Trade Commission has instituted Investigation No. 332–573, *Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels,* for the purpose of providing a report that examines the global economic impact of maximum residue level (MRL) policies.

DATES:

October 17, 2019: Deadline for filing requests to appear at the public hearing

October 21, 2019: Deadline for filing prehearing briefs and statements

October 29, 2019: Public hearing

November 5, 2019: Deadline for filing posthearing briefs

December 13, 2019: Deadline for filing all other written submissions for volume 1

April 30, 2020: Transmittal of volume 1 of Commission report to the USTR

June 5, 2020: Deadline for filing all other written submissions for volume 2

October 31, 2020: Transmittal of volume 2 of Commission report to the USTR (Delivered Monday, November 2, 2020)

ADDRESSES: All Commission offices, including the Commission's hearing rooms, are located in the United States International Trade Commission Building, 500 E Street SW, Washington, DC. All written submissions should be addressed to the Secretary, United States International Trade Commission, 500 E Street SW, Washington, DC 20436. The public record for this investigation may be viewed on the Commission's electronic docket (EDIS) at *https://edis.usitc.gov/edis3-internal/app.*

FOR FURTHER INFORMATION CONTACT: Project Leader Sabina Neumann (volumes 1 and 2) (202–205–3000 or *sabina.neumann@usitc.gov*) or Deputy Project Leader (volume 1) Steven LeGrand (202–205–3094 or *steven.legrand@usitc.gov*) or Deputy Project Leader (volume 2) Justin Choe (202–205–3229 or *justin.choe@usitc.gov*) for information specific to this investigation. For information on the legal aspects of this investigation, contact William Gearhart of the Commission's Office of the General Counsel (202–205–3091 or *william.gearhart@usitc.gov*). The media should contact Margaret O'Laughlin, Office of External Relations (202–205–1819 or *margaret.olaughlin@usitc.gov*). Hearing-impaired individuals may obtain information on this matter by contacting the Commission's TDD terminal at 202–205–1810. General information concerning the Commission may also be obtained by accessing its website (*https://www.usitc.gov*). Persons with mobility impairments who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202–205–2002.

Background: As requested by the USTR, under section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)), the Commission will conduct an

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investigation and prepare a report on the global economic impact of national maximum residue level (MRL) policies on plant protection products, with a focus on the impacts that low and missing standards have on agricultural trade. The USTR requested that the report include, to the extent practicable, information and analysis regarding the economic impact of pesticide MRLs on farmers in countries representing a range of income classifications (*e.g.,* low income, lower middle income, upper middle income, etc.) as well as the United States. The letter further requested that, to the extent information is available, the report cover the years 2016–2019, or the latest three years that data are available, but may, where appropriate, examine longer-term trends.

More specifically, the USTR asked that the report include the following:

(1) An overview of the role of plant protection products and their MRLs in relation to global production, international trade, and food safety for consumers. Describe the current and expected challenges to global agricultural production, including the impact of evolving pest and diseases pressures in differing regions and climates.

(2) A broad description of the approaches taken in setting national and international MRLs for crops. Describe the risk-based approach to setting MRLs in the context of agricultural trade, including the guidelines and principles of the Codex Alimentarius. Describe the procedures in the Codex Alimentarius for setting pesticide MRLs, including the role of the FAO/WHO Joint Meeting on Pesticide Residues (JMPR) in conducting risk assessments. Compare this risk-based approach to a hazard-based approach. Describe U.S. efforts to advance the use of lower-risk pesticides globally.

(3) A description of how MRLs for plant protection products are developed and administered in major markets for U.S. agricultural exports. Describe the specific regulations, processes, practices, and timelines in these major markets for establishing, modifying, and administering MRLs. Describe specific MRL enforcement practices and processes, including practices and procedures for addressing non-compliant imported plant products. Provide examples of how Codex MRLs are adopted into national legislation or regulation. Identify trade-facilitative practices and processes.

(4) A description of challenges and concerns faced by exporting countries in meeting importing country pesticide MRLs, such as when MRLs are missing or low. Explain the reasons for missing and low MRLs.

(5) Through case studies, describe the costs and effects of MRL compliance and non-compliance for producers in countries representing a range of income classifications, such as uncertainty in planting decisions, segregation of products, crop protection costs, yield implications, storage issues, product losses, and consequences of MRL violations. Include information on costs of adopting new plant protection products or those related to establishing, modifying, or testing for new or existing MRLs in export markets. To the extent possible, include effects on producers in countries with tropical climates where products are subject to high levels of pest and disease pressure.

(6) A review of the economic literature that assesses both qualitatively and quantitatively how missing and low MRLs affect countries representing a range of income classifications, particularly low income countries, with regard to production, exports, farmer income, and prices.

(7) Through case studies, describe the costs and effects or MRL compliance and non-compliance for U.S. producers, such as uncertainty in planting decisions, segregation of products, crop protection costs, yield implications, storage issues, product losses, and consequences of MRL violations. Include information on costs of adopting new plant protection products or those related to establishing, modifying, or testing for new or existing MRLs in export markets. To the extent possible, include effects on U.S. producers of specialty crops.

(8) To the extent possible, quantitatively and qualitatively assess how missing and low MRLs affect production, exports, farmer income, and prices, both on the national level and, to the extent possible, for small and medium size farms.

The USTR asked that the Commission prepare its report in two volumes, with volume 1 covering bullets (1)–(6) above transmitted by April 30, 2020, and volume 2 covering bullets (7)–(8) transmitted by October 31, 2020 (delivered on Monday, November 2, 2020).

Public Hearing: The Commission will hold a public hearing in connection with this investigation at the U.S. International Trade Commission Building, 500 E Street SW, Washington, DC, beginning at 9:30 a.m. on October 29, 2019. Persons wishing to appear at the public hearing should file a request to appear with the Secretary, no later than 5:15 p.m., October 17, 2019, in accordance with the requirements in the ''Submissions'' section below. All pre-hearing briefs and statements should be filed no later than 5:15 p.m., October 21, 2019; and all post-hearing briefs and statements responding to matters raised at the hearing should be filed no later than 5:15 p.m., November 5, 2019. In the event that, as of the close of business on October 17, 2019, no witnesses are scheduled to appear at the hearing, the hearing will be canceled. Any person interested in attending the hearing as an observer or nonparticipant should contact the Office of the Secretary at 202–205–2000 after October 17, 2019, for information concerning whether the hearing will be held.

Written Submissions: In lieu of or in addition to participating in the hearing, the Commission invites interested parties to submit written statements concerning this investigation. All written submissions should be addressed to the Secretary, and should be received no later than 5:15 p.m., December 13, 2019 for matters to be covered by volume 1 of the Commission's report, and June 3, 2020 for matters to be covered by volume 2 of the Commission's report. All written submissions must conform with the provisions of section 201.8 of the Commission's *Rules of Practice and Procedure* (19 CFR 201.8). Section 201.8 of the Rules (as further explained in the Commission's *Handbook on Filing Procedures*) requires that interested parties file documents electronically on or before the filing deadline and submit eight (8) true paper copies by 12:00 p.m. Eastern Time on the next business day. In the event that confidential treatment of a document is requested, interested parties must file, at the same time as the eight paper copies, at least four (4) additional true paper copies in which the confidential information must be deleted (see the following paragraph for further information regarding confidential business information or ''CBI''). Persons with questions regarding electronic filing should contact the Office of the Secretary, Docket Services Division (202–205–1802).

Confidential Business Information (CBI): Any submissions that contain CBI must also conform to the requirements of section 201.6 of the *Commission's Rules of Practice and Procedure* (19 CFR 201.6). Section 201.6 of the Rules requires that the cover of the document and the individual pages be clearly marked as to whether they are the ''confidential'' or ''non-confidential'' version, and that the CBI is clearly identified using brackets. The Commission will make all written submissions, except for those (or portions thereof) containing CBI, available for inspection by interested parties.

In his request letter, the USTR stated that his office intends to make the Commission's report available to the public in its entirety, and asked that the Commission not include any CBI in the report that it delivers to the USTR.

The Commission will not include any of the CBI submitted in the course of this investigation in the report it sends to the USTR. However, all information, including CBI, submitted in this investigation may be disclosed to and used (i) by the Commission, its employees and Offices, and contract personnel (a) for developing or maintaining the records of this or a related proceeding, or (b) in internal investigations, audits, reviews, and evaluations relating to the programs, personnel, and operations of the Commission, including under 5 U.S.C. Appendix 3; or (ii) by U.S. government employees and contract personnel for cybersecurity purposes. The Commission will not otherwise disclose any CBI in a manner that would reveal the operations of the firm supplying the information.

Summaries of Written Submissions: The Commission intends to publish any summaries of written submissions filed by interested persons. Persons wishing to have a summary of their submission included in the report should include a summary with their written submission, titled "Public Summary," and should mark the summary as having been provided for that purpose. The summary may not exceed 500 words, should be in MSWord format or a format that can be easily converted to MSWord, and should not include any CBI. The summary will be published as provided if it meets these requirements and is germane to the subject matter of the investigation. The Commission will identify the name of the organization furnishing the summary and will include a link to the Commission's Electronic Document Information System (EDIS) where the full written submission can be found.

By order of the Commission.

Issued: September 23, 2019.

Lisa Barton,

Secretary to the Commission.

[FR Doc. 2019–20959 Filed 9–26–19; 8:45 am]

BILLING CODE 7020–02–P

DEPARTMENT OF JUSTICE

Notice of Lodging of Proposed Consent Decree Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as Amended

On September 19, 2019, the United States of America ("United States"), through attorneys for the Department of Justice, and the Commonwealth of Pennsylvania, Department of Environmental Protection ("PADEP"), lodged a proposed Consent Decree with the United States District Court for the Middle District of Pennsylvania in the lawsuit entitled *United States et al.* v. *Foster Wheeler Energy Corporation,* Civil Action No. 3:19–cv–01620–UN4.

In their Complaint, also filed on September 19, 2019, pursuant to Sections 106, 107(a), and 113(g) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended ("CERCLA"), 42 U.S.C. 9606, 9607(a), and 9613(g), and pursuant to Sections 507 and 1103 of the Hazardous Sites Cleanup Act, Act of October 18, 1988, Public Law 756, 35 P.S. §§ 6020.507 and 6020.1103 ("HSCA"), the United States and PADEP ("Plaintiffs") allege that Defendant Foster Wheeler Energy Corporation ("FWEC") is liable for cleanup costs incurred and to be incurred by the United States and PADEP in connection with the cleanup of the Foster Wheeler Energy Corporation/Church Road TCE Superfund Alternative Site ("Site") in Mountain Top, Luzerne County, Pennsylvania. The Site includes a former industrial site used to manufacture and fabricate large pressure vessels that was formerly owned and operated by FWEC (the "Former FWEC Facility"). The Site also includes any areas at which hazardous substances released at or from this facility have come to be located, including an area of groundwater contamination located south and southwest of the Former FWEC Facility and encompassing approximately 295 acres of mixed land use (mainly residential), which extends from east to west along Church Road and Watering Run, and eight surrounding industrial properties located immediately south and west of the Former FWEC Facility.

The proposed Consent Decree resolves all allegations asserted in the Plaintiffs' Complaint and provides for FWEC to pay to the United States Environmental Protection Agency ("EPA") $950,000.00 in past response costs incurred with respect to the Site, and to pay to PADEP $56,051.21 in past state response costs incurred with respect to the Site. These payments are due within thirty (30) days after the Consent Decree becomes effective as a judgment, if it is entered by the Court. The proposed Consent Decree also requires FWEC to pay the United States' and PADEP's future response costs and to perform the Interim Remedy selected in EPA's Interim Record of Decision for the Site. In exchange, FWEC receives from both Plaintiffs covenants not to sue for the interim remedial work performed and payment of past and future federal and state response costs, subject to certain reservations and limitations.

The publication of this notice opens a federal period for public comment on the Consent Decree. Comments should be addressed to the Assistant Attorney General, Environment and Natural Resources Division, and should refer to *United States et al.* v. *Foster Wheeler Energy Corporation,* D.J. Ref. No. 90–11–3–12044. All comments must be submitted no later than 30 days after the publication date of this notice. Comments may be submitted either by email or by mail:

To submit comments:	*Send them to:*
By email	*pubcomment-ees.enrd@usdoj.gov.*
By mail	Assistant Attorney General, U.S. DOJ—ENRD, P.O. Box 7611, Washington, DC 20044–7611.

During the public comment period, the Consent Decree may be examined and downloaded at this Justice Department website: *https://www.justice.gov/enrd/consent-decrees.* We will provide a paper copy of the Consent Decree upon written request and payment of reproduction costs. Please mail your request and payment to: Consent Decree Library, U.S. DOJ—ENRD, P.O. Box 7611, Washington, DC 20044–7611.

Please enclose a check or money order for $39.50 (0.25 cents per page reproduction cost) payable to the United States Treasury for a copy of the full Consent Decree with appendices. For a paper copy without the appendices, the cost is $12.00.

Jeffrey Sands,

Assistant Chief, Environmental Enforcement Section, Environment and Natural Resources Division.

[FR Doc. 2019–20966 Filed 9–26–19; 8:45 am]

BILLING CODE 4410–15–P

21456 Federal Register / Vol. 85, No. 75 / Friday, April 17, 2020 / Notices

draft Criteria for Developing Refuge Water Management Plans 2020 (2020 Refuge Criteria) for public review and comment. Reclamation is publishing this notice in order to allow the public an opportunity to review the draft 2020 Refuge Criteria.

DATES: Submit written comments on the preliminary determinations on or before May 18, 2020.

ADDRESSES: Send written comments to Mr. David T. White, Bureau of Reclamation, 2800 Cottage Way, CGB–410, Sacramento, CA 95825; or via email at *dwhite@usbr.gov.*

FOR FURTHER INFORMATION CONTACT: To be placed on a mailing list for any subsequent information, please contact Mr. White at *dwhite@usbr.gov* or at 916–978–5208 (TDD 978–5608).

SUPPLEMENTARY INFORMATION: Section 3405(e) of the Central Valley Project Improvement Act (Title 34 Pub. L. 102–575) requires the Secretary of the Interior to, among other things, ‘‘develop criteria for evaluating the adequacy of all water conservation plans’’ developed by certain contractors. According to Section 3405(e)(1), these criteria must promote ‘‘the highest level of water use efficiency reasonably achievable by project contractors using best available cost-effective technology and best management practices.’’ In accordance with this legislative mandate, the Bureau of Reclamation developed and published the Refuge Criteria, which is updated every 3 years.

We invite the public to comment on our preliminary (*i.e.,* draft) 2020 Refuge Criteria.

A copy of the draft 2020 Refuge Criteria will be available for review at Reclamation's office in Sacramento, California, located at 2800 Cottage Way, CGB–410, Sacramento, CA 95825. If you wish to review a copy of the draft 2020 Refuge Criteria or receive an electronic copy via email, please contact Mr. White or visit *https://www.usbr.gov/mp/watershare.*

Sheryl Looper,

Acting Regional Resources Manager,Bureau of Reclamation, California-Great Basin—Interior Region 10.

[FR Doc. 2020–08155 Filed 4–16–20; 8:45 am]

BILLING CODE 4332–90–P

INTERNATIONAL TRADE COMMISSION

[Investigation No. 332–573]

Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels; Notice of Change in Completion Date, Clarification of Deadline for Filing Written Submissions

AGENCY: United States International Trade Commission.

ACTION: Change in date for transmittal of volume 1 of the Commission's report; clarification of a filing date relating to volume 2 of the report; and waiver of the requirement to file paper copies.

SUMMARY: The Commission has changed the date for transmittal of volume 1 of its report to the U.S Trade Representative (USTR) in this investigation from April 30, 2020 to June 30, 2020 due to COVID–19; is clarifying that the due date for written submission for volume 2 of its report is June 5, 2020; and has waived the requirement to file paper copies of those submissions.

DATES:

June 5, 2020: Deadline for filing all other written submissions for volume 2

June 30, 2020: Transmittal of volume 1 of Commission report to the USTR

October 31, 2020: Transmittal of volume 2 of Commission report to the USTR (Delivered Monday, November 2, 2020)

ADDRESSES: All written submissions should be addressed to the Secretary, United States International Trade Commission, 500 E Street SW, Washington, DC 20436. The public record for this investigation may be viewed on the Commission's electronic docket (EDIS) at *https://edis.usitc.gov/edis3-internal/app.*

FOR FURTHER INFORMATION CONTACT: Project Leader Sabina Neumann (volumes 1 and 2) (202–205–3000 or *sabina.neumann@usitc.gov*) or Deputy Project Leader (volume 1) Steven LeGrand (202–205–3094 or *steven.legrand@usitc.gov*) or Deputy Project Leader (volume 2) Justin Choe (202–205–3229 or *justin.choe@usitc.gov*) for information specific to this investigation. For information on the legal aspects of this investigation, contact William Gearhart of the Commission's Office of the General Counsel (202–205–3091 or *william.gearhart@usitc.gov*). The media should contact Margaret O'Laughlin, Office of External Relations (202–205–1819 or *margaret.olaughlin@usitc.gov*). Hearing-impaired individuals may obtain information on this matter by contacting the Commission's TDD terminal at 202–205–1810. General information concerning the Commission may also be obtained by accessing its website (*https://www.usitc.gov*). Persons with mobility impairments who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202–205–2002.

SUPPLEMENTARY INFORMATION: The Commission published notice of institution of the above referenced investigation in the **Federal Register** on September 27, 2019 (84 FR 51178, September 27, 2019). In that notice the Commission stated that it would transmit volume 1 of its report to the USTR by April 30, 2020. However, due to COVID–19 and in accordance with a request on behalf of Ambassador Robert Lighthizer, the U.S. Trade Representative, the Commission will transmit volume 1 of its report to the USTR by June 30, 2020. This notice also corrects an ambiguity in the September 27, 2019 notice by clarifying that written submissions relating to volume 2 of the report should be filed with the Commission by June 5, 2020 (the original notice in one place gave June 3, 2020, as the due date). All other dates pertaining to this investigation remain the same as in the notice published in the **Federal Register** on September 27, 2019.

Written Submissions: In lieu of or in addition to participating in the hearing, the Commission invites interested parties to submit written statements concerning this investigation. All written submissions should be addressed to the Secretary, and should be received no later than 5:15 p.m., June 5, 2020 for matters to be covered by volume 2 of the Commission's report. All written submissions must conform with the provisions of section 201.8 of the Commission's *Rules of Practice and Procedure* (19 CFR 201.8). Section 201.8 of the Rules (as further explained in the Commission's *Handbook on Filing Procedures*) requires that interested parties file documents electronically on or before the filing deadline (see the following paragraph for further information regarding confidential business information or ''CBI''). Persons with questions regarding electronic filing should email the Office of the Secretary, Docket Services Division at *EDIS3Help@usitc.gov.* The Commission has waived the requirement in section 201.8(d)(1) of its rules (19 CFR 201.8(d)(1)) that persons filing written submissions must also file paper copies of their written submissions by noon of the next day; no paper copies should be filed.

Confidential Business Information (CBI): Any submissions that contain CBI must also conform to the requirements of section 201.6 of the *Commission's Rules of Practice and Procedure* (19 CFR 201.6). Section 201.6 of the Rules requires that the cover of the document and the individual pages be clearly marked as to whether they are the ''confidential'' or ''non-confidential'' version, and that the CBI is clearly identified using brackets. The Commission will make all written submissions, except for those (or portions thereof) containing CBI, available for inspection by interested parties.

In his request letter, the USTR stated that his office intends to make the Commission's report available to the public in its entirety and asked that the Commission not include any CBI in the report that it delivers to the USTR.

The Commission will not include any of the CBI submitted in the course of this investigation in the report it sends to the USTR. However, all information, including CBI, submitted in this investigation may be disclosed to and used (i) by the Commission, its employees and Offices, and contract personnel (a) for developing or maintaining the records of this or a related proceeding, or (b) in internal investigations, audits, reviews, and evaluations relating to the programs, personnel, and operations of the Commission, including under 5 U.S.C. Appendix 3; or (ii) by U.S. government employees and contract personnel for cybersecurity purposes. The Commission will not otherwise disclose any CBI in a manner that would reveal the operations of the firm supplying the information.

Summaries of Written Submissions: The Commission intends to publish any summaries of written submissions filed by interested persons. Persons wishing to have a summary of their submission included in the report should include a summary with their written submission, titled ''Public Summary,'' and should mark the summary as having been provided for that purpose. The summary may not exceed 500 words, should be in MSWord format or a format that can be easily converted to MSWord, and should not include any CBI. The summary will be published as provided if it meets these requirements and is germane to the subject matter of the investigation. The Commission will identify the name of the organization furnishing the summary and will include a link to the Commission's Electronic Document Information System (EDIS) where the full written submission can be found.

By order of the Commission.

Issued: April 13, 2020.

Lisa Barton,

Secretary to the Commission.

[FR Doc. 2020–08102 Filed 4–16–20; 8:45 am]

BILLING CODE 7020–02–P

INTERNATIONAL TRADE COMMISSION

[Investigation Nos. 701–TA–620 and 731–TA–1445 (Final)]

Wooden Cabinets and Vanities From China

Determinations

On the basis of the record [1] developed in the subject investigations, the United States International Trade Commission (''Commission'') determines, pursuant to the Tariff Act of 1930 (''the Act''), that an industry in the United States is materially injured by reason of imports of wooden cabinets and vanities from China, provided for in subheadings 9403.40.90, 9403.60.80, and 9403.90.70 of the Harmonized Tariff Schedule of the United States, that have been found by the U.S. Department of Commerce (''Commerce'') to be sold in the United States at less than fair value (''LTFV''), and to be subsidized by the government of China.

Background

The Commission instituted these investigations effective March 6, 2019, following receipt of petitions filed with the Commission and Commerce by the American Kitchen Cabinet Alliance. The final phase of these investigations was scheduled by the Commission following notification of preliminary determinations by Commerce that imports of wooden cabinets and vanities from China were subsidized within the meaning of section 703(b) of the Act (19 U.S.C. 1671b(b)) and sold at LTFV within the meaning of 733(b) of the Act (19 U.S.C. 1673b(b)). Notice of the scheduling of the final phase of the Commission's investigations and of a public hearing to be held in connection therewith was given by posting copies of the notice in the Office of the Secretary, U.S. International Trade Commission, Washington, DC, and by publishing the notice in the **Federal Register** on October 24, 2019 (84 FR 57050). The hearing was held in Washington, DC, on February 20, 2020, and all persons who requested the opportunity were permitted to appear in person or by counsel.

[1] The record is defined in sec. 207.2(f) of the Commission's Rules of Practice and Procedure (19 CFR 207.2(f)).

The Commission made these determinations pursuant to sections 705(b) and 735(b) of the Act (19 U.S.C. 1671d(b) and 19 U.S.C. 1673d(b)). It completed and filed its determinations in these investigations on April 13, 2020. The views of the Commission are contained in USITC Publication 5042 (April 2020), entitled *Wooden Cabinets and Vanities from China: Investigation Nos. 701–TA–620 and 731–TA–1445 (Final).*

By order of the Commission.

Issued: April 13, 2020.

Lisa Barton,

Secretary to the Commission.

[FR Doc. 2020–08091 Filed 4–16–20; 8:45 am]

BILLING CODE 7020–02–P

INTERNATIONAL TRADE COMMISSION

[Investigation No. 337–TA–1124]

Certain Powered Cover Plates; Commission Determination Not to Review a Remand Initial Determination; Schedule for Filing Written Submissions on Remedy, the Public Interest, and Bonding

AGENCY: U.S. International Trade Commission.

ACTION: Notice.

SUMMARY: Notice is hereby given that the U.S. International Trade Commission has determined not to review a remand initial determination (''RID'') issued by the presiding administrative law judge (''ALJ'') in the above-captioned investigation granting a motion for summary determination regarding whether certain redesigns infringe the asserted patents. The Commission requests briefing from the parties, interested government agencies, and interested persons on the issues of remedy, the public interest, and bonding.

FOR FURTHER INFORMATION CONTACT: Michael Liberman, Esq., Office of the General Counsel, U.S. International Trade Commission, 500 E Street SW, Washington, DC 20436, telephone (202) 205–3115. Copies of non-confidential documents filed in connection with this investigation are or will be available for inspection during official business hours (8:45 a.m. to 5:15 p.m.) in the Office of the Secretary, U.S. International Trade Commission, 500 E Street, SW, Washington, DC 20436, telephone (202) 205–2000. General

Federal Register / Vol. 85, No. 125 / Monday, June 29, 2020 / Notices 38923

INTERNATIONAL TRADE COMMISSION

[Investigation No. 332–573]

Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels; Extension of Time To File Written Submissions, and Delay in Submitting Volume 2 of the Report

AGENCY: United States International Trade Commission

ACTION: Extension of the Deadline for Filing Written Submissions in Connection with Volume 2 of the Report and Extension of the Time for Transmitting Volume 2 of the Report.

SUMMARY: The Commission has extended the deadline for filing written comments relating to volume 2 of its report from June 5, 2020, to July 31, 2020, and in accordance with a request on behalf of the U.S. Trade Representative (USTR), the Commission will submit volume 2 of its report by January 31, 2021 (delivered Monday, February 1, 2021) instead of by October 31, 2020.

DATES:

June 30, 2020: Transmittal of volume 1 of the report to the USTR (this date is unchanged)

July 31, 2020: New deadline for filing written submissions relating to volume 2

January 31, 2021: New transmittal date for volume 2 of the Commission's report to the USTR (Delivered Monday, February 1, 2021)

ADDRESSES: All written submissions should be addressed to the Secretary, United States International Trade Commission, 500 E Street SW, Washington, DC 20436. The public record for this investigation may be viewed on the Commission's electronic docket (EDIS) at *https://edis.usitc.gov/*.

FOR FURTHER INFORMATION CONTACT: Project Leader Sabina Neumann (volumes 1 and 2) (202–205–3000 or *sabina.neumann@usitc.gov*) or Deputy Project Leader (volume 2) Brian Daigle (202–205–3458 or *brian.daigle@usitc.gov*) for information specific to this investigation. For information on the legal aspects of this investigation, contact William Gearhart of the Commission's Office of the General Counsel (202–205–3091 or *william.gearhart@usitc.gov*). The media should contact Margaret O'Laughlin, Office of External Relations (202–205–1819 or *margaret.olaughlin@usitc.gov*). Hearing-impaired individuals may obtain information on this matter by contacting the Commission's TDD terminal at 202–205–1810. General information concerning the Commission may also be obtained by accessing its website (*https://www.usitc.gov*). Persons with mobility impairments who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202–205–2002.

SUPPLEMENTARY INFORMATION: The Commission published notice of institution of the above referenced investigation in the **Federal Register** on September 27, 2019 (84 FR 51178, September 27, 2019). The Commission instituted the investigation following receipt of a request from the USTR on August 30, 2019. The USTR asked that the Commission provide its report in two volumes, with volume 1 provided by June 30, 2020, and volume 2 by October 31, 2020. In its notice announcing the investigation, the Commission noted the respective due dates for volumes 1 and 2 of the report, and in connection with volume 2, requested that written submissions be filed with the Commission by June 5, 2020. On May 28, 2020, the Commission received a request on behalf of the U.S. Trade Representative, requesting that the Commission deliver volume 2 of its report by January 31, 2021. That request noted the disruption and technical issues that have arisen with respect to completion of volume 2 of the report due to the COVID–19 pandemic, including with respect to the ability to do travel-related research, and asked that the Commission transmit volume 2 of the report by January 31, 2021 (delivered Monday, February 1, 2021). The Commission still expects to transmit volume 1 of the report to USTR by June 30, 2020, the date indicated in the notice published in the **Federal Register** on April 17, 2020.

Written Submissions: The Commission has invited interested parties to submit written statements concerning this investigation. All written submissions should be addressed to the Secretary, and should be received no later than 5:15 p.m., July 31, 2020 for matters to be covered by volume 2 of the Commission's report. All written submissions must conform with the provisions of section 201.8 of the Commission's *Rules of Practice and Procedure* (19 CFR 201.8). Section 201.8 of the Rules (as further explained in the Commission's *Handbook on Filing Procedures*) requires that interested parties file documents electronically on or before the filing deadline (see the following paragraph for further information regarding confidential business information or ''CBI''). Persons with questions regarding electronic filing should contact the Office of the Secretary, Docket Services Division (202–205–1802). The Commission has waived the requirement in section 201.8(d)(1) of its rules (19 CFR 201.8(d)(1)) that persons filing written submissions must also file paper copies of their written submissions by noon of the next day; accordingly, no paper copies should be filed, nor should copies be filed in any form other than electronic.

Confidential Business Information (CBI): Any submissions that contain CBI must also conform to the requirements of section 201.6 of the *Commission's Rules of Practice and Procedure* (19 CFR 201.6). Section 201.6 of the Rules requires that the cover of the document and the individual pages be clearly marked as to whether they are the ''confidential'' or ''non-confidential'' version, and that the CBI is clearly identified using brackets. The Commission will make all written submissions, except for those (or portions thereof) containing CBI, available for inspection by interested parties.

In his request letter, the USTR stated that his office intends to make the Commission's report available to the public in its entirety, and he asked that the Commission not include any CBI in the report that it delivers to USTR.

The Commission will not include any of the CBI submitted in the course of this investigation in the report it sends to the USTR. However, all information, including CBI, submitted in this investigation may be disclosed to and used (i) by the Commission, its employees and Offices, and contract personnel (a) for developing or maintaining the records of this or a related proceeding, or (b) in internal investigations, audits, reviews, and evaluations relating to the programs, personnel, and operations of the Commission, including under 5 U.S.C. Appendix 3; or (ii) by U.S. government employees and contract personnel for cybersecurity purposes. The Commission will not otherwise disclose any CBI in a manner that would reveal the operations of the firm supplying the information.

Summaries of Written Submissions: The Commission intends to publish any summaries of written submissions filed by interested persons. Persons wishing to have a summary of their submission included in the report should include a summary with their written submission, titled ''Public Summary,'' and should mark the summary as having been provided for that purpose. The summary may not exceed 500 words, should be in MSWord format or a format that can be easily converted to MSWord, and should not include any CBI. The summary will be published as provided if it meets these requirements and is germane to the subject matter of the investigation. The Commission will identify the name of the organization furnishing the summary and will include a link to the Commission's Electronic Document Information System (EDIS) where the full written submission can be found.

By order of the Commission.

Issued: June 23, 2020.

Lisa Barton,

Secretary to the Commission.

[FR Doc. 2020–13883 Filed 6–26–20; 8:45 am]

BILLING CODE 7020–02–P

DEPARTMENT OF JUSTICE

FY 2017 and FY 18 Service Contracts Inventory and Inventory Supplement

AGENCY: Justice Management Division, Department of Justice.

ACTION: Notice.

SUMMARY: In accordance with Section 743 of Division C of the FY 2010 Consolidated Appropriations Act, the Department of Justice is publishing this notice to advise the public of the availability of its FY 2017 and FY 18 Service Contracts Inventory and Inventory Supplement. The inventory includes service contract actions over $25,000 that were awarded in Fiscal Year (FY) 2017 and 2018. The inventory supplement includes information collected from contractors on the amount invoiced and direct labor hours expended for covered service contracts. The Department of Justice analyzes this data for the purpose of determining whether its contract labor is being used in an effective and appropriate manner and if the mix of federal employees and contractors in the agency is effectively balanced. The inventory and supplement do not include contractor proprietary or sensitive information. The FY 2017 and 2018 Service Contract Inventory and Inventory Supplements are provided at the following link: *https://www.justice.gov/jmd/service-contract-inventory.*

FOR FURTHER INFORMATION CONTACT: Kevin Doss, Office of Acquisition Management, Justice Management Division, U.S. Department of Justice, Washington, DC 20530; Phone: 202–616–3758; Email: *Kevin.Doss@usdoj.gov*

Dated: June 24, 2020.

Melody Braswell,

Department Clearance Officer for PRA, U.S. Department of Justice.

[FR Doc. 2020–13979 Filed 6–26–20; 8:45 am]

BILLING CODE 4410–DH–P

DEPARTMENT OF LABOR

Employment and Training Administration

Notice of Determinations Regarding Eligibility to Apply for Trade Adjustment Assistance

In accordance with the Section 223 (19 U.S.C. 2273) of the Trade Act of 1974 (19 U.S.C. 2271, *et seq.*) (''Act''), as amended, the Department of Labor herein presents summaries of determinations regarding eligibility to apply for trade adjustment assistance under Chapter 2 of the Act (''TAA'') for workers by (TA–W) number issued during the period of *May 1, 2020 through May 31, 2020.* (This Notice primarily follows the language of the Trade Act. In some places however, changes such as the inclusion of subheadings, a reorganization of language, or ''and,'' ''or,'' or other words are added for clarification.)

Section 222(a)—Workers of a Primary Firm

In order for an affirmative determination to be made for workers of a primary firm and a certification issued regarding eligibility to apply for TAA, the group eligibility requirements under Section 222(a) of the Act (19 U.S.C. 2272(a)) must be met, as follows:

(1) The first criterion (set forth in Section 222(a)(1) of the Act, 19 U.S.C. 2272(a)(1)) is that a significant number or proportion of the workers in such workers' firm (or ''such firm'') have become totally or partially separated, or are threatened to become totally or partially separated; AND (2(A) or 2(B) below)

(2) The second criterion (set forth in Section 222(a)(2) of the Act, 19 U.S.C. 2272(a)(2)) may be satisfied by either (A) the Increased Imports Path, or (B) the Shift in Production or Services to a Foreign Country Path/Acquisition of Articles or Services from a Foreign Country Path, as follows:

(A) Increased Imports Path:

(i) the sales or production, or both, of such firm, have decreased absolutely; AND (ii and iii below)

(ii)(I) imports of articles or services like or directly competitive with articles produced or services supplied by such firm have increased; OR

(II)(aa) imports of articles like or directly competitive with articles into which one or more component parts produced by such firm are directly incorporated, have increased; OR

(II)(bb) imports of articles like or directly competitive with articles which are produced directly using the services supplied by such firm, have increased; OR

(III) imports of articles directly incorporating one or more component parts produced outside the United States that are like or directly competitive with imports of articles incorporating one or more component parts produced by such firm have increased; AND

(iii) the increase in imports described in clause (ii) contributed importantly to such workers' separation or threat of separation and to the decline in the sales or production of such firm; OR

(B) Shift in Production or Services to a Foreign Country Path OR Acquisition of Articles or Services from a Foreign Country Path:

(i) (I) there has been a shift by such workers' firm to a foreign country in the production of articles or the supply of services like or directly competitive with articles which are produced or services which are supplied by such firm; OR

(II) such workers' firm has acquired from a foreign country articles or services that are like or directly competitive with articles which are produced or services which are supplied by such firm; AND

(ii) the shift described in clause (i)(I) or the acquisition of articles or services described in clause (i)(II) contributed importantly to such workers' separation or threat of separation.

Section 222(b)—Adversely Affected Secondary Workers

In order for an affirmative determination to be made for adversely affected secondary workers of a firm and a certification issued regarding eligibility to apply for TAA, the group eligibility requirements of Section 222(b) of the Act (19 U.S.C. 2272(b)) must be met, as follows:

(1) A significant number or proportion of the workers in the workers' firm or an appropriate subdivision of the firm have become totally or partially separated, or are threatened to become totally or partially separated; AND

(2) the workers' firm is a supplier or downstream producer to a firm that employed a group of workers who received a certification of eligibility under Section 222(a) of the Act (19 U.S.C. 2272(a)), and such supply or production is related to the article or

Appendix C
Calendar of Hearing Witnesses

CALENDAR OF PUBLIC HEARING

Those listed below are scheduled to appear as witnesses at the United States International Trade Commission's hearing:

Subject: Global Economic Impact of Missing and Low Pesticide Maximum Residue Levels

Inv. No.: 332-573

Date and Time: October 29, 2019 - 9:30 a.m.

A session was held in connection with this investigation in the Main Hearing Room (Room 101), 500 E Street, SW., Washington, DC.

EMBASSY APPEARANCES:

Embassy of the Republic of Paraguay
Washington, DC

The Honorable Minister Luis González Fernández, Deputy Chief of Mission

Taipei Economic and Cultural Representative Office
Washington, DC

James Tsai, Economic Officer

PANEL 1:

ORGANIZATION AND WITNESS:

U.S. Hop Industry Plant Protection Committee
Yakima, WA

Alinne Oliveira, Trade Policy Specialist, Bryant Christie Inc.

Northwest Horticultural Council
Yakima, WA

Dr. David Epstein, Vice President, Scientific Affairs

The Cranberry Institute
Carver, MA

Terry L. Humfeld, Executive Director

PANEL 2:

ORGANIZATION AND WITNESS:

U.S. Sweet Potato Council
Dillsburg, PA

Kay Swartz Rentzel, Executive Director

USA Dry Pea & Lentil Council
Moscow, ID

Dale Thorenson, Gordley Associates

CropLife America
Washington, DC

Christopher Novak, President and Chief Executive Officer

- END -

Appendix D
Summary of Views of Interested Parties

Interested parties had the opportunity to file written submissions to the Commission in the course of this investigation and to provide summaries of the positions expressed in the submissions for inclusion in this report. This appendix contains these written summaries, provided that they meet certain requirements set out in the notice of investigation. The Commission has not edited these summaries. This appendix also contains the names of other interested parties who filed written submissions during investigation but did not provide written summaries. A copy of each written submission is available in the Commission's Electronic Docket Information System (EDIS), https://www.edis.usitc.gov. The Commission also held a public hearing in connection with this investigation on October 29, 2019. The full text of the transcript of the Commission's hearing is also available on EDIS.

Written Submissions

Almond Board of California

No written summary. Please see EDIS for full submission.

American Farm Bureau Federation

No written summary. Please see EDIS for full submission.

American Peanut Council

No written summary. Please see EDIS for full submission.

American Pistachio Growers

No written summary. Please see EDIS for full submission.

American Soybean Association

No written summary. Please see EDIS for full submission.

Australian Government Department of Agriculture

Australia appreciates the opportunity to provide a written submission to the United States International Trade Commission (US ITC) Investigation into the Global Economic Impact of Missing and Low Pesticide Maximum Residue Limits (MRLs). The effect of missing or low MRLs impacts stakeholders at multiple points along the Global Value Chain, including both exporting and importing economies. Australia has long been a leader in recognising the need for science and risk based decision making processes that facilitate trade while still providing the appropriate level of protection for consumers.

Effective, efficient and sustainable agricultural production is critical to ensure an increasing global population has access to sufficient food sources. In order to meet this challenge, one of the key requirements is to provide farmers with the full suite of agricultural production technologies. It is also important to recognise that each economy experiences different biosecurity challenges, and that the need for pesticide use that comes with these challenges is different.

Australia has a robust regulatory system that allows for both the setting of MRLs for domestic use, and the establishment of MRLs for imported produce where there are differences. The system is jointly regulated by the Australia Pesticides and Veterinary Medicines Authority and Food Standards Australia

New Zealand. Supporting these functions is comprehensive residue monitoring programs undertaken by the government and private businesses to ensure that Australian agricultural produce meets the relevant MRLs.

We support this through a range of multi-lateral fora, including through Asia-Pacific Economic Cooperation (APEC). Developing the APEC Import MRL Guideline for Pesticides has supported strong collaboration between economies and raised the profile of the benefits of harmonised systems. Further advocacy of this work will benefit the global community and provide an avenue to effectively and efficiently address the challenge of missing MRLs.

We are encouraged by the US initiative to gather global information on the economic impact of missing and low MRLs, and will continue to support work that addresses these problems. Measures by industry to manage this issue, including restricted trade programs and cessation on the use of some pesticides is not sustainable and adds an additional layer of cost and complexity to farmers and industry.

Australia continues to advocate internationally the benefits of our systems and the need for economies to support the setting and adoption of Codex MRLs. We encourage the international community to look at the Australian system as best practice and how it can be used as a positive example when considering policy decisions on MRLs in their own economies. Addressing the impact of missing and low pesticide MRLs, by having a system to allow import MRLs be established, has positively facilitated trade, decreased the rejection of food at the border and increased consumers choice of food available. In support of the US ITC for undertaking this work, Australia is happy to provide this written submission, detailing our systems and providing that knowledge to other economies and industry.

Bayer

No written summary. Please see EDIS for full submission.

California Cherry Board

No written summary. Please see EDIS for full submission.

California Citrus Mutual

No written summary. Please see EDIS for full submission.

California Citrus Quality Council

No written summary. Please see EDIS for full submission.

California Fresh Fruit Association

No written summary. Please see EDIS for full submission.

California Rice Commission

The California Rice Commission a statutory organization representing 2,500 rice growers and marketers producing the crop on an average of 500,000 acres. California is the second largest producing state growing mostly temperate japonica rice.

Our comments provide responses to the eight items listed in the public notice.

1) Half the crop is consumed domestically with shipments to countries utilizing our rice such as Taiwan, Korea, Turkey with Japan the largest market. We manage regulatory programs for California rice and, as an USA Rice member, coordinate on several programs including trade. Rice is a global commodity and the temperate japonica varieties are common in sushi, risotto and paella. An emerging armyworm problem expanding on a global basis is taxing availability of the most effective product for control.

2) For evaluating MRLs from foreign countries, we utilize Title 40 Code of Federal Regulations for pesticide tolerances established by the U.S. Environmental Protection Agency Office of Pesticide Programs (U.S. EPA OPP). The tolerances are United States MRLs established at the conclusion of the review process for pesticide registration. Pesticides sold and used in the United States are registered by the U.S. EPA OPP. Every state has a registration process for licensing the pesticide. California has a program that reviews and registers pesticides sold and used before they are eligible for licensing. As a result, California rice has fewer registered pesticides than other rice producing states. We provide the numbers and reference to the U.S. EPA OPP website for information on pesticide tolerances and background on Codex.

3) We receive WTO notices on adoption of Codex MRLs and our review includes comparison to the U.S. EPA OPP tolerances. We provide information on the number of chemicals we analyze in shipments to Japan.

4) Our comments outline two areas of concern on missing and low MRLs. The first relates to a missing MRL in one country we export rice. The second issue is the proposal to lower an MRL on a significant rice herbicide. These examples of missing and low MRLs could result in trade irritants.

5) The comment we provide briefly outlines the timeline for pesticide registration. The process could allow for harmonization by utilizing the U.S. EPA OPP review materials in establishing MRLs for commodities from the United States.

6) We provide an example of the impact a country could experience in banning three pesticides.

7) California rice has no impacts. We provide a scenario if the MRL on an herbicide is lowered to the proposed level.

8) Rice is family farmed, yet our small to medium acreage could be considered large in other countries. We provide examples of potential trade irritants from missing and low MRLs. The cost of holding a shipment at a foreign port is significant.

Our final message suggests collaboration at a governmental level through an agency to agency streamlined and effective approach. We realize our recommendation is a simple method to a complex issue. However, we have experience where the commitment to collaboration has proven effective and positive.

California Table Grape Commission

No written summary. Please see EDIS for full submission.

California Walnut Commission

No written summary. Please see EDIS for full submission.

Chilean Fresh Fruit Exporters Association

No written summary. Please see EDIS for full submission.

Cranberry Institute

No written summary. Please see EDIS for full submission.

CropLife America and CropLife International

No written summary. Please see EDIS for full submission.

European Commission

The European Union (EU)is an accessible and open market that is committed to free trade. it is the second biggest importer worldwide of agricultural (food &feed) products with €116 billion worth of imports. The US is one of the great beneficiaries of a highly attractive and open EU-market for imported food & feed: EU agri-food imports from the USA were the fastest growing imports in 2018 and, with an impressive 12% increase, the EU became the third top destination for US agri-food exports after Canada and Mexico.

Pesticide residues resulting from the use of plant protection products (PPPs) on crops or food products that are used for food or feed production may pose a risk for public health. Each exporting country therefore needs to be in a position to meet the EU's food safety standards. The EU legislative regime on PPPs is transparent, predictable, and based on international standards and the best available science. Before an active substance can be approved in the EU it must undergo a thorough approval procedure carried out jointly by a Member State of the EU and the European Food Safety Authority (EFSA), the EU's independent risk assessment body for food and feed safety which assures that risk assessments are free from undue influence. The Authority is founded on the core values of independence, scientific excellence, transparency, and openness and uses internationally agreed risk assessment methodologies. A key part of this approval process is an assessment of risks to consumers. Plant protection products containing such approved substances must then be authorized by the EU Member States in a second step.

Additionally, the EU sets' pesticide maximum residue levels (MRLs)for each crop based on EFSA's risk assessment that apply indiscriminately to domestic and imported products placed on the EU market. The EU aligns its MRLs with Codex MRLs in the vast majority of cases: the EU has taken on board 1833 MRI: out of 2567 CXLs adopted by Codex between 2012 and 2,019 and is aligned with more than 70 percent of the CXLs established in this period.

The EU legislation provides for a review of the existing MRLs of all approved and certain nonapproved PPPs. The EU allows non-EU countries to request import tolerances even for active substances which are not authorised in the EU. Import tolerances permit EU-MRLs to be set based on Good Agricultural Practices (GAPs) authorised in non-EU countries at a level sufficiently high to meet the needs of international trade. Potential applicants, including foreign governments and exporters, have access to the risk assessment authorities at EU and Member State level, and the data they submit are always taken into account before decisions on MRLs and import tolerances are taken.

Compliance with Food Safety standards for EU produced and imported products is verified on the basis of samples taken in a proportionate and non-discriminatory manner. There are currently no US-products subject to reinforced checks due to pesticide MRLs exceeding statutory limits.

Government of Canada

No written summary. Please see EDIS for full submission.

IR-4 Project Headquarters

No written summary. Please see EDIS for full submission.

National Potato Council

No written summary. Please see EDIS for full submission.

Northwest Horticultural Council

No written summary. Please see EDIS for full submission.

North American Blueberry Council

No written summary. Please see EDIS for full submission.

Pesticide Policy Coalition

No written summary. Please see EDIS for full submission.

Phytosanitary Agency of Chile

No written summary. Please see EDIS for full submission.

Taipei Economic and Cultural Representation Office in the United States

No written summary. Please see EDIS for full submission.

U.S. Grains Council, National Corn Growers Association, MAIZALL

No written summary. Please see EDIS for full submission.

U.S. Wheat Associates

No written summary. Please see EDIS for full submission.

U.S.A. Rice Federation

No written summary. Please see EDIS for full submission.

U.S. Environmental Protection Agency

No written summary. Please see EDIS for full submission.

U.S. Hop Industry Plant Protection Committee

No written summary. Please see EDIS for full submission.

U.S. Sweet Potato Council

No written summary. Please see EDIS for full submission.

Wine Institute and the California Association of Winegrape Growers

No written summary. Please see EDIS for full submission.

Appendix E
Technical Appendix: Calculating MRL Indices

Homologa Historical Dataset

The MRL data reflected in this report are sourced from the Homologa Historical Dataset from Lexagri[527]. This time series panel of MRL data spanning from 2005 to 2016 for over 50 countries was used to develop the underlying foundation for the gravity model framework, the MRL indices. Each year of data is contained in a separate file, and countries or groups are added or removed (e.g., from harmonization to a group) throughout the sample. Each row in this dataset includes a country (or group of harmonized countries), a crop (general group and specific crop), a registered active ingredient/substance (abbreviated “active” throughout this section), and a numerical MRL value. Only countries that maintain positive lists available to Homologa are included in this dataset. Given the enormity of the raw data, some aggregations and transformations were made to the dataset to more easily link it with trade and production data for analytical purposes. These changes are documented in this appendix.

Three transformations are made to the dataset to make it easier to use and concord with trade and production datasets. The first transformation is aggregating crops according to classifications of the Food and Agriculture Organization of the United Nations (FAO). This step was undertaken because the Homologa Historical Dataset uses highly disaggregated crop descriptions and countries use different naming schemes. FAO classifications that fall outside the scope of this report (e.g., animal products) are also removed during this step. The second transformation is aggregating active ingredients/substances, or “actives.” Active ingredient/substance names are not necessarily consistent across countries or years, and some countries use broader classifications than others. Similarly named actives were grouped and flagged for review by a chemical expert on the Commission staff. With both types of aggregation, if a country had multiple crops or actives that were aggregated, the average MRL for those crops or actives was used for the new aggregated row. Table E.1 shows pre- and post-aggregation numbers for total rows, actives, and crops.

The final data transformation involves imputing all possible default rules. The historical data do not include default rules for each year. As a result, Commission staff compiled country-specific default rules from current MRL data.[528] These current default rules are applied to the historical dataset to create a comprehensive list of every possible applied MRL. This means that for each crop, every country has a listed applied MRL for every active for which at least one country has a listed MRL for that crop-active combination. This information is included in the “Number of rows after all default rules are applied (step 3)” column of table E.1. The usage of applied MRLs is described in greater detail below.

[527] Lexagri International, Homologa historical database (accessed February 6, 2020). Lexagri collected MRLs and import tolerances from countries with positive lists, harmonizing crops across countries when possible and translating information into English. The historical dataset consists of one snapshot of the database per year.
[528] Lexagri International, Homologa database (accessed November 11, 2020).

Table E.1 Summary of MRL data before and after data were aggregated

Year	Number of rows in original database	Number of rows after aggregation (steps 1&2)	Number of rows after all default rules are applied (step 3)	Number of markets	Number of active ingredients in original database	Number of active ingredients after aggregation (step 2)	Number of crops in original database	Number of crops after aggregation (step 1)
2005	607,346	240,901	1,576,428	28	903	823	1,614	113
2006	1,127,715	405,319	2,572,882	34	1,017	920	1,797	111
2007	1,424,213	585,971	3,342,200	40	1,078	995	1,546	111
2008	1,790,850	715,815	3,888,765	45	1,105	1,031	1,647	110
2009	1,835,839	731,918	4,199,856	48	1,127	1,050	1,668	111
2010	2,016,890	763,886	4,192,080	48	1,127	1,049	1,686	111
2011	848,147	244,607	1,684,020	26	987	918	1,536	110
2012	889,766	254,464	1,712,360	26	989	920	1,503	110
2013	928,737	308,353	2,457,568	32	1,034	962	1,592	109
2014	1,071,888	333,442	2,502,240	32	1,060	982	1,631	110
2015	2,186,039	476,329	4,329,118	34	1,398	1,297	1,830	111
2016	2,440,519	546,392	4,343,568	34	1,392	1,289	1,850	111
2017	2,727,108	609,241	4,367,844	34	1,408	1,302	1,920	111
2018	2,883,803	627,534	4,511,868	34	1,467	1,344	2,131	114

Source: Lexagri International, Homologa historical dataset with aggregation and cleaning by USITC staff.

Imputing Applied MRLs

A key aspect of this report is analyzing missing and default MRLs. These pose a unique challenge for the international modeling due to the number and variety of crops and pesticides that are all analyzed within the same framework. The approach used for both international models involves imputing applied MRLs using countries' default rules for missing MRLs, and then aggregating these applied MRLs into stringency and heterogeneity indices.

This process is done separately for each year. First, the Homologa historical data file for that year is loaded. Any observations that have missing or non-numeric MRL values are not included in the analysis. The first step is to group crops and active ingredients/substances to make them more consistent within the dataset and more consistent with external datasets.

For crops, Commission staff created a concordance from the Homologa crop list to the FAO list. Crops that are out of the scope of this report, including processed goods, animals, and animal products, were removed from analysis. This was done to make the results usable with FAO data on trade and production. It was also a necessary step due to inconsistent naming and organization conventions across countries in the Homologa dataset—some countries may list a single, broader crop while others may use very specific subvarieties on their list.

For active substances/ingredients (pesticides), similar inconsistencies in naming and level of detail were identified. The Commission created an algorithm that identified active substances that had similar names but different endings (for example, if an active substance had a letter designation at the end, some countries may use a hyphen before that letter, while others might use parentheses). The list of active substances with near-duplicate names, along with information on the spread of MRL values on those actives within country-crop pairs, was reviewed by a chemical expert on the Commission's staff who identified which actives were actually identical or nearly identical and which actives were not.

MRLs were grouped by the new crop-active pairs and averaged within each country, resulting in each MRL being identified by the year, the country, the (FAO) crop, and the (possibly corrected) active. This cleaned dataset, which was essentially a collection of each country's positive lists, was used as the basis for the applied MRLs. This was done by creating comprehensive lists of all actives used by any country for each crop. That dataset includes two MRL columns, one for the original MRL (if present) and one for the applied MRL. If an original MRL existed, it was also used as the applied MRL.

If an original MRL was not provided, then the applied MRL was initialized as an empty cell to be filled in by the default rules. Default rules are set at the country level (i.e., all crops for a country use the same rule); they were provided by Homologa separately from the historical data and were compiled by Commission staff. Default rules are a sequential list of alternative values to use when an MRL value is missing. The first applicable alternative value is used. Some countries just have a single, numerical value (e.g., 0.1ppm) as their only default rule that is always applied. Others list other countries or entities as a reference (e.g., the United States or Codex Alimentarius, etc.) to which they defer as long as the reference has an MRL listed for the specified crop and active pair. All default rules end with a numerical value that should be assigned if none of the alternative defaults are applicable. If no such numerical value is explicitly identified by the country, or if the country has no default rule listed at all, then zero tolerance (a numerical value of 0.0) is assumed. At the end of this process, if a country has no original MRLs for a given crop, then a placeholder is created using the numerical default rule that can be used to calculate the index when the market is an importer.

Calculating the MRL Indices

Heterogeneity Index

The heterogeneity index shows the differences between the applied MRLs of two countries. The index is the average of scaled differences between the exporter MRL and the importer MRL. This is calculated by subtracting the importer MRL from the exporter MRL, then dividing the difference by the average applied MRL across all countries. The index cannot go below zero but is unbounded from above. Note that the denominator is calculated from the full sample of countries and groups, not just the exporter and importer—the value is the same for any pair of countries comparing the same crop-active pair.

The index values are different when the exporter and the importer are switched. There are two reasons for this. The first is that for each active considered, the differences are bounded by zero. That means that if the exporter is more restrictive than the importer for a specific active, that difference will contribute a zero to the average rather than a negative value. This bound is often applied in the MRL literature based on the assumption that it is not challenging for an exporter to meet importer MRL requirements if the exporter rule is already stricter. The second reason that the order of the pair matters is that the selection of actives considered is based on the list of original MRLs for the exporting country. That means that default rules are only applied for the importer. This selection of actives was chosen to best represent the meaning of "missing" MRLs, since any issues related to missing MRLs would be expected to occur if the exporter uses (and therefore has an MRL for) an active. The only exception to this rule is when the exporter has no actives approved for a given crop, in which case the index is calculated by comparing the default rules of the two countries to avoid having undefined values in the heterogeneity index.

The equation for this index is given below; $aMRL$ denotes an applied MRL (which may be original or from a default rule), X denotes the exporter, M denotes the importer, c denotes a crop, $P_{c,X}$ denotes the set of actives (pesticides) approved for crop c by the exporter X, and p denotes a given pesticide from set $P_{c,X}$.

$$MRL\ Heterogeneity\ Index_{XMc} = \frac{1}{P_{c,X}} \sum_{p \in P_{c,X}} \frac{max\left(0, aMRL_{Xcp} - aMRL_{Mcp}\right)}{mean(aMRL_{cp})}$$

Stringency Index

The stringency index is a unilateral measure of a country's MRLs for a given crop. It is calculated as the average value of the MRLs applied for the nine most common actives across all countries. Here, "most common" is defined as the actives that occur most often as original MRLs for the specified crop, taking into account all countries and groups contained in that year's dataset. Default rules are not used when identifying the most common actives, but they are applied when a country is missing an MRL for that active.

Higher values of the stringency index indicate higher MRLs, which corresponds to less-restrictive MRLs. Since MRLs cannot be negative, this index will never go below zero, but it is unbounded from above. The simple average approach, along with restricting focus to common actives, was chosen in order to reduce potential collinearity between the stringency index and the heterogeneity index by having sufficiently different structures for the two indices.

The equation for this index is given below; $aMRL$ denotes an applied MRL (which may be original or from a default rule), M denotes the country, c denotes a crop, N denotes the number of globally common actives being considered, and p denotes a specific pesticide from that set. The report uses $N = 9$ for the size of the set of common actives.

$$MRL\ Stringency\ Index_{Mc} = \frac{1}{N} \sum_{p=1}^{N} \mathrm{aMRL_{Mcp}}$$

MRL Trends

The number of new MRLs available to growers can vary over time. For banana growers in the markets studied here, each year is typically very low in the number of new banana MRLs, and in some years no new MRLs are added at all. Codex, for example, added only 5 MRLs between 2015 and 2018 (table E.2). In a few cases, a large batch of new MRLs may be added in a single year, but these additions occur inconsistently and are not coordinated across markets. Generally, adding MRLs for active substances will make a market comparatively less stringent (lower heterogeneity index), since a default rule will no longer be applied for that active. However, this will make other markets seem more stringent by comparison, since the market that added the active will now need to meet importer default rules for markets that have not approved the active.

Table E.2 Bananas: MRLs added to the positive list, select markets (2005–18)
Some values in cells are marked with footnote letter a, meaning the market had zero approved active ingredients for the banana in that year. Note: values indicate the number of MRLs added to the positive list relative to the previous year. Some active ingredients indicated as added at the start of the time series in 2005 may have actually been present on the list before the data were collected.

Market	’05	’06	’07	’08	’09	’10	’11	’12	’13	’14	’15	’16	’17	’18
Australia	73	8	16	9	1	0	2	1	6	2	11	14	9	39
Brazil	31	0	2	0	0	3	0	1	0	0	2	5	1	0
Canada	7	0	0	4	0	1	2	1	5	4	10	1	6	3
China	24	0	8	0	18	0	0	7	37	9	0	0	13	0
European Union	[a]	[a]	[a]	450	18	10	25	20	58	7	559	8	23	10
Japan	64	0	304	0	1	37	3	0	329	16	8	32	4	47
South Korea	64	2	0	35	12	14	25	0	8	27	281	14	7	8
Morocco	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	7	0	0	0
Mexico	[a]	23	0	0	5	0	0	0	1	0	0	0	0	11
United States	48	1	8	2	0	1	2	3	6	2	1	2	1	37
South Africa	[a]	[a]	29	0	0	0	0	0	0	0	0	0	0	0
Codex	40	1	[a]	42	0	8	0	2	6	1	1	1	0	3

Source: Lexagri International, Homologa Historical Dataset with aggregation and cleaning by USITC staff.

Changes to existing MRLs on a market’s positive list do sometimes occur, but they are usually infrequent and often impact only a small number of existing MRLs. Table E.3 illustrates how existing MRLs have either increased or decreased on a year-to-year basis for bananas among selected markets between 2005 and 2018. While adjustments to existing MRLs are not made annually in every market, certain markets more frequently adjust MRLs than others. For example, the EU reduced existing MRLs on bananas (making them more restrictive) in 8 out of the 11 years in this period, while Codex MRLs for bananas were reduced only twice in 14 years. The EU also increased MRLs on some actives approved for bananas, but the increases occurred at a much lower rate (1 percent) than the reductions to existing MRL levels (varying between 1 and 41 percent).

The magnitude of an MRL increase or decrease is important for exporters, but so are other factors. Table E.3 shows how many MRLs increased or decreased but not how much the individual MRLs increased or decreased, or how many MRLs are available for alternative pesticides. In cases where growers may depend on a key pesticide with few close substitutes, the effects of a reduction in MRLs would be disproportionately greater for exporters who heavily rely on that specific pesticide. The impacts of such a change, along with several other scenarios, are explored more fully in chapter 4. The construction of the MRL stringency index, discussed in greater detail in chapter 3 also addresses this issue.

Table E.3 Bananas: Percentage of existing MRLs increasing or decreasing, select markets (2005–18)

Values show the percentage of existing MRLs that increased or decreased in value compared to the previous year, rounded to 1 percentage point. This table does not include MRLs added to or removed from a market's positive list. Some values in cells are marked with footnote letter a, meaning the market had no reported MRLs for this crop in the given year. Values in cells marked with footnote letter b indicate markets that had reported MRLs for this crop in this year, but either the market had no reported MRLs for this crop in the previous year or the latest year with reported MRLs was earlier than 2005 and was out of the sample.

Market	Change	’05	’06	’07	’08	’09	’10	’11	’12	’13	’14	’15	’16	’17	’18
Australia	Decrease	[b]	0	1	1	0	0	0	0	5	0	1	4	2	3
Australia	Increase	[b]	0	4	6	0	0	0	1	3	0	0	8	0	0
Brazil	Decrease	[b]	0	0	0	0	0	0	0	0	3	0	3	0	2
Brazil	Increase	[b]	0	3	3	0	3	0	0	0	0	6	0	5	0
Canada	Decrease	[b]	0	0	0	0	0	0	0	0	0	0	0	0	0
Canada	Increase	[b]	0	0	0	0	11	0	0	0	0	0	0	0	0
China	Decrease	[b]	0	0	0	3	0	0	22	0	0	0	0	0	0
China	Increase	[b]	0	0	0	7	0	0	6	17	0	0	0	3	0
European Union	Decrease	[a]	[a]	[a]	[b]	1	1	0	0	1	6	41	6	1	1
European Union	Increase	[a]	[a]	[a]	[b]	0	1	0	0	1	1	1	1	1	0
Japan	Decrease	[b]	0	5	0	0	4	0	0	5	1	4	2	1	2
Japan	Increase	[b]	2	2	0	0	0	0	0	0	0	0	0	0	0
South Korea	Decrease	[b]	0	0	2	3	5	9	0	0	1	1	83	0	0
South Korea	Increase	[b]	0	0	0	0	0	0	0	1	5	29	1	6	0
Morocco	Decrease	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[b]	0	0	0
Morocco	Increase	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[b]	0	0	0
Mexico	Decrease	[a]	[b]	0	0	10	0	0	0	0	0	0	0	0	4
Mexico	Increase	[a]	[b]	0	0	0	0	0	0	9	0	0	0	0	0
United States	Decrease	[b]	2	7	0	2	0	0	0	0	0	2	2	0	0
United States	Increase	[b]	0	2	0	2	4	0	0	2	0	0	2	0	0
South Africa	Decrease	[a]	[a]	[b]	0	0	0	0	0	0	0	0	0	0	0
South Africa	Increase	[a]	[a]	[b]	0	0	0	0	0	0	0	0	0	0	0
Codex	Decrease	[b]	0	[a]	[b]	0	20	0	0	2	0	0	0	0	0
Codex	Increase	[b]	3	[a]	[b]	17	0	0	0	2	0	0	2	0	0

Source: Lexagri International, Homologa Historical Dataset with aggregation and cleaning by USITC staff.

[a] Market had no reported MRLs for this crop in this year.

[b] Market had reported MRLs for this crop in this year, but either the market had no reported MRLs for this crop in the previous year or the latest year with reported MRLs was earlier than 2005 and was out of the sample.

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Lexagri International. Homologa historical database. https://v5.homologa.com/en/home (accessed February 6, 2020; subscription required).

Appendix F
Technical Appendix: Gravity Model

Gravity Model Overview

This appendix describes the technical details of the gravity framework used for the analysis presented in chapter 3. It first describes the empirical version of the model used to estimate the direct effects of maximum residue levels (MRLs) on trade. Second, it describes the simulation model extension used to estimate the broader, general equilibrium effects of MRLs.

The Empirical Gravity Model

The empirical gravity model used for this report is representative of typical structural gravity models in the economic literature. It is based on the theoretical foundations of the gravity model approach described in several seminal works, including those by Anderson and van Wincoop (2003) and Eaton and Kortum (2002). See the first equation, labeled (Gravity) in the next section ("Simulation Model") for a presentation of the theoretical gravity model.[529]

The econometric version of the model follows the best practices described by Yotov et al. (2016) and Head and Mayer (2014).[530] It took the following form:

$$X_{ijst} = exp\left(\alpha z_{ijst} + INT_{ijs}\left(\beta + \gamma MRL_{ijst}^{div} + \delta MRL_{ijst}^{str}\right) + \mu_{ist} + \nu_{jst}\right) + \epsilon_{ijst} \quad (Empirical)$$

Here, X_{ijst} denotes bilateral trade from exporter *i* to importer *j* of crop *s* in year *t*. z_{ijst} is a vector of customary trade cost measures that include distance, contiguity, common language, colonial ties, preferential trade agreements (PTAs), and joint European Union (EU) membership. INT_{ijs} is a dummy variable that takes the value of 1 if the trade flow is international ($i \neq j$) and 0 if it is domestic ($i = j$). The International indicator appears in the model independently via the coefficient β and as an interaction term on two MRL indexes MRL_{ijst}^{div} and MRL_{jst}^{str}, which respectively denote the heterogeneity and stringency indexes described elsewhere in this chapter. The model includes exporter-year and importer-year fixed effects, denoted by μ_{ist} and ν_{jst}, which represent important controls for the multilateral resistance terms described by Anderson and van Wincoop (2003).[531]

The model was estimated separately for each crop group based on the inherent separability of the structural gravity model.[532] Estimating each crop individually allowed for different estimates of each coefficient and fixed effect for each crop. This was done in order to better control for and estimate the heterogeneous effects of MRLs and other factors across different crops.

Notably, the model specification used in this report diverges from many of those in past papers evaluating the economic effects of MRLs, such as those of Winchester et al. (2012) and Xiong and Beghin (2014).[533] The most notable divergence is the introduction of domestic shipments, which made it

[529] Anderson and van Wincoop, "Gravity with Gravitas," 2003; Eaton and Kortum, "Technology, Geography, and Trade," 2002.
[530] Yotov et al., "An Advanced Guide," 2016; Head and Mayer, "Gravity Equations: Workhorse, Toolkit, and Cookbook," 2014.
[531] Anderson and van Wincoop, "Gravity with Gravitas," 2003.
[532] Yotov et al., "An Advanced Guide," 2016.
[533] Winchester et al., "The Impact of Regulatory Heterogeneity," 2012; Xiong and Beghin, "Disentangling Demand-Enhancing and Trade-Cost Effects," 2014.

possible to identify international and domestic trade costs separately. Importantly, introducing domestic shipments provided a means by which to mitigate issues with collinearity between the MRL indexes and the country-year fixed effects. The problem was that within each sector, the MRLs and country fixed effects are defined at the same level: country-year. This implies that the stringency index, which is a country-year measure, and the heterogeneity index, which is the linear combination of importer-year and exporter-year measures, exhibit collinearities with the structurally important fixed effects. To solve this issue, the MRL indexes were interacted with the indicator for international trade, thereby severing the collinearity with the fixed effects.[534] This interaction means that the estimated effects of MRLs ought to be interpreted as specific to international trade separate from any effects that MRLs may have on domestic trade costs, which are captured in the fixed effects.

The estimation of the model followed modern best practices and used the Poisson pseudo-maximum likelihood (PPML) estimator proposed by Santos Silva and Tenreyro (2006).[535] The PPML estimator provides several notable advantages over linear approaches because it permits the inclusion of zero-trade flows, which was done here, and provides better treatment of the heteroskedasticity that is prevalent in trade data.[536] The analysis was conducted using the Commission's Gravity Modeling Environment (GME) Python package.[537]

The data used in the model were derived from three sources. Bilateral trade data came from FAOSTAT.[538] The data for international flows were constructed as the average of the reported imports and exports between countries *i* and *j*, which was done to help mitigate reporting inaccuracies and inconsistencies. Domestic shipments were defined as the difference between total production and total exports within each year and were constructed using FAOSTAT domestic production data.[539] In cases where reported exports exceeded production within the year, domestic shipments were set equal to zero. As described in appendix E, the MRL data underlying the two indexes were sourced from Homologa. Finally, the remaining gravity variables were taken from the Dynamic Gravity dataset.[540] These variables included the distance between countries, contiguity (shared borders), common languages, preferential trade agreements (PTAs), joint EU membership (both countries belonging to the European Union), and colonial ties.

The model estimates for the non-MRL variables are depicted in figure F.1. Each plot in the figure depicts the coefficient estimates for each sector of the respective variable. Although there is some heterogeneity in estimates across sectors, most are consistent with standard gravity results. The estimates for the International term are mostly negative, confirming the expectation that crossing an international border represents a barrier to trade in most sectors. Similarly, the Distance estimates

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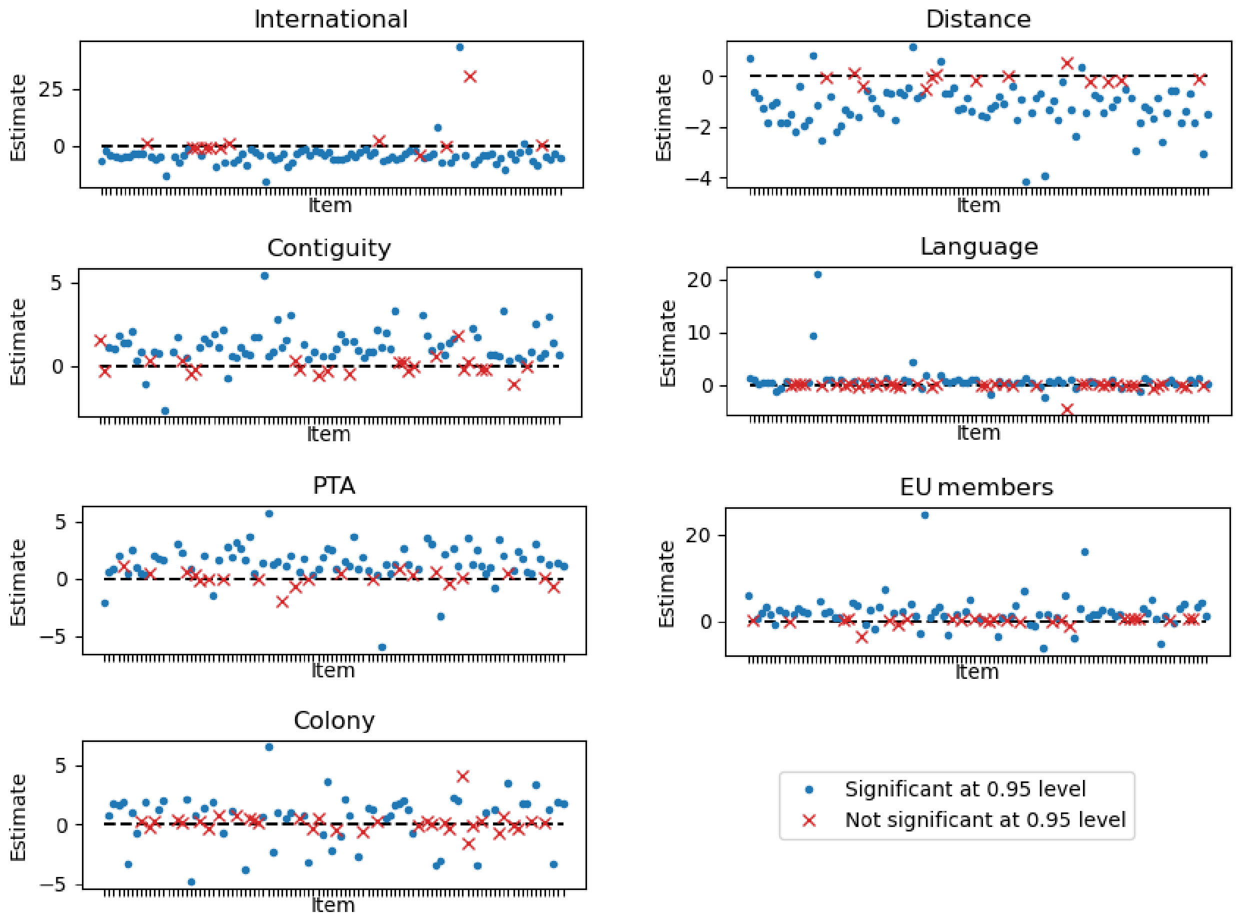
[534] See Heid, Larch, and Yotov, "Estimating the Effects," 2017, for a more detailed explanation of using domestic shipments to help estimate the effects of nondiscriminatory trade costs.
[535] Santos Silva and Tenreyro, "The Log of Gravity," 2006.
[536] Heteroskedacity refers to cases in which the variability of an independent variable is unequal for different values of the dependent variable.
[537] USITC, Gravity Portal: GME, updated May 2019.
[538] FAO, FAOSTAT (accessed October 29, 2019).
[539] FAO, FAOSTAT (accessed October 29, 2019).
[540] Gurevich and Herman, "The Dynamic Gravity Dataset," 2018. Details on the construction of the Dynamic Gravity dataset are presented in its technical documentation, which can be found at https://www.usitc.gov/sites/default/files/data/gravity/dynamic_gravity_technical_documentation_v1_00_1.pdf.

indicate that the distance between markets acts as a barrier to trade. The remaining variables—Contiguity, Language, PTA, EU membership, and Colony (colonial ties)—all show positive effects on trade in most cases, suggesting that they are generally trade facilitating.

Figure F.1 Plot of gravity coefficient estimates for the non-MRL variables



Source: USITC estimates.

The estimated effects of MRLs for each crop are presented in table F.1. Each row concerns a different crop. The first cell in each row shows how much the stringency of importer MRLs affects bilateral trade values for the crop; the second shows the statistical significance of the estimated effect; the third shows the standard error of the estimate. Likewise, the fourth cell shows how much the heterogeneity of an importer MRL affects bilateral trade values; the fifth shows the statistical significance of the estimated effect; and the sixth shows the standard error of the estimate. Within the table, crops are sorted from largest to smallest by the average yearly total value of trade and domestic shipments.

Table F.1 Estimated effects of MRLs on bilateral trade values with respect to importer MRLs' stringency and heterogeneity

Note: The asterisks (stars) that are attached to estimate values report the statistical significance of the estimates: *** indicates p < 0.01, ** indicates p < 0.05, and * indicates p < 0.10 where p denotes the probability that the true value is equal to zero (i.e., that the measure has no impact on bilateral trade). Superscripts labeled 1 indicate p > = 0.1. N.e.s. = not elsewhere specified.

Crop	Import MRL stringency estimate	Import MRL stringency statistical significance[a]	Import MRL stringency standard error	MRL heterogeneity estimate	MRL heterogeneity statistical significance[a]	MRL heterogeneity standard error	Mean annual value (million $)
Maize	1.191	***	0.105	-0.589	***	0.087	193,219
Wheat	0.473	***	0.108	-0.388	*	0.209	160,914
Soybeans	1.248	***	0.334	-0.882	***	0.259	97,937
Potatoes	0.070	*	0.037	-0.384	***	0.120	87,647
Tomatoes	0.414	**	0.166	-0.091	[1]	0.107	83,640
Vegetables, fresh, n.e.s.	0.545	***	0.083	-0.252	***	0.057	77,472
Grapes	0.221	***	0.015	0.008	[1]	0.087	60,326
Apples	-0.028		0.117	-0.283	***	0.073	51,977
Bananas	0.499	**	0.204	-1.143	***	0.166	38,910
Watermelons	1.232	***	0.293	-0.847	***	0.162	33,452
Onions, dry	0.551	***	0.172	0.219	***	0.038	31,606
Rapeseed	0.301	[1]	0.223	-0.338	**	0.164	29,829
Cucumbers and gherkins	1.521	***	0.204	-0.446	***	0.162	29,303
Barley	0.149	*	0.080	-0.377	***	0.085	27,420
Beans, all	0.657	***	0.072	-0.287	***	0.057	27,389
Mangoes, mangosteens, guavas	0.545	***	0.186	-0.956	***	0.147	26,520
Chillies and peppers, green	-0.195	[1]	0.345	0.031	[1]	0.068	26,249
Sweet potatoes	-1.788	*	1.034	-0.271	[1]	0.202	26,231
Oranges	-0.275	*	0.143	-0.586	***	0.101	23,238
Coffee, green	-0.263	[1]	3.300	-0.270	***	0.066	21,036
Olives	0.745	***	0.242	-1.051	***	0.204	20,692
Tobacco, unmanufactured	0.695	[1]	0.548	-0.081	***	0.014	19,661
Garlic	0.111	**	0.056	-0.633	***	0.068	19,111
Cabbages and other brassicas	0.645	***	0.089	0.028	[1]	0.057	18,560
Eggplants (aubergines)	2.309	***	0.414	-0.517	**	0.211	17,891
Peaches and nectarines	0.113	**	0.056	-0.296	***	0.100	15,596
Sunflower seed	0.402	***	0.068	-0.566	***	0.082	15,583
Lettuce and chicory	0.092	**	0.039	-0.126	***	0.047	15,123
Pears	-0.110	[1]	0.107	-0.108	[1]	0.085	14,453

Crop	Import MRL stringency estimate	Import MRL stringency statistical significance[a]	Import MRL stringency standard error	MRL heterogeneity estimate	MRL heterogeneity statistical significance[a]	MRL heterogeneity standard error	Mean annual value (million $)
Tangerines, mandarins, clementines, satsumas	-0.390	***	0.100	-0.195	***	0.072	14,443
Strawberries	0.265	***	0.080	-0.268	***	0.071	14,021
Tea	-0.253	***	0.040	-0.367	***	0.052	13,861
Peas, all	-0.007	[1]	0.160	-0.004	[1]	0.063	13,661
Sorghum	0.340	*	0.183	-0.575	**	0.259	13,530
Mushrooms and truffles	-0.012	[1]	0.035	-0.014	[1]	0.027	12,666
Sugar beet	-0.078	[1]	2.486	-0.217	[1]	0.137	12,544
Melons, other (including cantaloupes)	1.164	***	0.211	-0.589	***	0.130	12,280
Carrots and turnips	0.083	[1]	0.105	0.093	**	0.038	12,071
Spinach	0.898	***	0.112	-0.332	***	0.083	11,626
Fruit, tropical fresh n.e.s.	-0.366	*	0.201	-0.464	***	0.130	11,086
Walnuts, with shell	1.707	***	0.587	-0.183	**	0.086	10,840
Cauliflowers and broccoli	0.307	*	0.161	-0.284	***	0.059	10,633
Fruit, fresh n.e.s.	0.047	[1]	0.072	-0.479	***	0.067	10,311
Almonds, with shell	0.090	[1]	0.169	-0.241	[1]	0.317	10,040
Lemons and limes	0.031	[1]	0.115	-0.756	***	0.109	10,028
Coconuts	0.340	[1]	0.946	-0.065	[1]	0.104	9,717
Cocoa, beans	26.756	***	3.082	-0.027	[1]	0.066	9,638
Pineapples	-0.752	***	0.244	-0.307	***	0.094	9,507
Cottonseed	-4.166	[1]	4.587	-0.090	[1]	0.135	9,277
Millet	-0.501	*	0.281	-0.591	***	0.221	9,182
Dates	-0.283	*	0.148	-0.041	[1]	0.083	9,149
Asparagus	1.624	***	0.122	-0.583	***	0.098	8,942
Plums and sloes	-0.138	**	0.058	0.159	*	0.087	8,632
Plantains and others	-7.591	***	2.304	0.921	**	0.366	8,533
Pumpkins, squash and gourds	0.191	[1]	0.248	-0.755	***	0.131	7,625
Chick peas	-2.244	***	0.511	-0.094	**	0.038	6,991
Honey, natural	-18.140	***	4.648	0.105	***	0.031	6,431
Pistachios	1.335		1.059	-0.729	***	0.253	5,149
Maize, green	-1.885	*	1.113	0.275	**	0.135	4,911
Chillies and peppers, dry	-0.170	***	0.044	-0.217	***	0.082	4,655

Crop	Import MRL stringency estimate	Import MRL stringency statistical significance[a]	Import MRL stringency standard error	MRL heterogeneity estimate	MRL heterogeneity statistical significance[a]	MRL heterogeneity standard error	Mean annual value (million $)
Cherries	0.709	***	0.092	-0.177	[1]	0.131	4,419
Avocados	0.713	***	0.173	-0.634	***	0.135	4,351
Sesame seed	4.003	***	0.623	0.091	*	0.052	4,336
Papayas	0.733	***	0.153	0.246	***	0.090	3,938
Oats	0.093	[1]	0.089	-0.404	*	0.212	3,921
Cashew nuts, with shell	1.982	[1]	2.170	0.308	**	0.146	3,814
Chestnut	0.666	**	0.259	-0.090	[1]	0.061	3,721
Grapefruit (including pomelos)	-0.544	***	0.152	-1.039	***	0.157	3,395
Onions, shallots, green	0.502	***	0.160	-0.290	***	0.086	3,152
Lentils	1.765	***	0.465	-0.091	**	0.045	3,052
Rye	0.130	[1]	0.105	-0.604	***	0.142	2,919
Apricots	-0.003	[1]	0.115	-0.140	[1]	0.097	2,751
Hazelnuts, with shell	0.865	[1]	1.057	0.380	*	0.204	2,601
Persimmons	-0.288	[1]	1.622	-0.376	**	0.162	2,596
Pepper (*Piper* spp.)	-0.008	[1]	0.015	-0.054	*	0.030	2,568
Triticale	-0.203	[1]	0.189	0.078	[1]	0.219	2,517
Kiwi fruit	0.340	*	0.178	-0.259	***	0.058	2,468
Leeks, other alliaceous vegetables	0.264	***	0.052	0.220	***	0.042	2,338
Ginger	1.622	[1]	1.560	-0.025	[1]	0.109	2,148
Anise, badian, fennel, coriander	0.089	[1]	0.055	0.064	**	0.029	1,884
Oilseeds n.e.s.	3.032	***	0.624	0.094	**	0.042	1,669
Blueberries	0.153	***	0.052	-0.292	***	0.046	1,523
Linseed	0.622	[1]	0.502	-0.373	***	0.106	1,209
Artichokes	-0.325	[1]	0.558	0.009	[1]	0.099	1,124
Cranberries	-0.867	***	0.293	-0.348	***	0.091	990
Cherries, sour	-0.173	[1]	0.681	-0.578	***	0.177	971
Currants	0.236	**	0.113	-0.796	***	0.135	964
Figs	-0.229	***	0.060	-0.116	**	0.047	895
Buckwheat	-0.369	[1]	0.309	-0.364	**	0.156	738
Hops	0.047	***	0.017	-0.084	**	0.039	727
Nutmeg, mace and cardamoms	2.052	[1]	1.782	0.083	[1]	0.067	578
Gooseberries	-0.978	*	0.504	-0.922	***	0.226	428
Mustard seed	0.496	[1]	0.926	-0.240	***	0.051	405
Cloves	-0.012	[1]	0.016	-0.033	[1]	0.033	344
Quinces	-1.186	***	0.234	-0.258	*	0.142	316
Fibre crops n.e.s.	4.118	***	0.973	-0.328	***	0.035	310
Vanilla	0.059	*	0.031	0.127	**	0.051	276

Crop	Import MRL stringency estimate	Import MRL stringency statistical significance[a]	Import MRL stringency standard error	MRL heterogeneity estimate	MRL heterogeneity statistical significance[a]	MRL heterogeneity standard error	Mean annual value (million $)
Poppy seed	1.170	[1]	1.229	0.561	***	0.165	228
Quinoa	-0.193	[1]	65534.580	-0.027	[1]	0.107	190
Pyrethrum, dried	-0.541	[1]	48097.160	-0.025	[1]	0.025	51
Peppermint	-2.897	**	1.216	-0.077	[1]	0.135	<1

Source: USITC estimates.

Simulation Model

To capture a fuller range of effects from lowering MRLs, a version of the gravity model suited for simulation was used to evaluate the likely effects of the European Union lowering its MRLs by 90 percent. The simulation model used for this analysis was based on the model described by Yotov et al. (2016).[541] The model builds on the earlier theoretical gravity model of Anderson and van Wincoop (2003) as well as several other popular trade models that yield comparable gravity frameworks.[542] The model is given by the following system of equations.

$$X_{ij} = \frac{Y_i E_j}{Y}\left(\frac{t_{ij}}{P_j \Pi_i}\right)^{1-\sigma} \qquad (Gravity)$$

$$\Pi_i^{1-\sigma} = \sum_i \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{E_j}{Y} \qquad (OMR)$$

$$P_j^{1-\sigma} = \sum_j \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma} \frac{Y_i}{Y} \qquad (IMR)$$

$$p_i = \left(\frac{Y_i}{Y}\right)^{\frac{1}{1-\sigma}} \frac{1}{\alpha_i P_i} \qquad (Prices)$$

$$E_i = \phi_i Y_i = \phi_i P_i Q_i \qquad (Expenditure)$$

Equation (Gravity) depicts the standard gravity equation, in which bilateral exports from country *i* to country *j* are determined by the exporter's total output (Y_i), the importer's total expenditure (E_i), world output (Y), bilateral trade costs (t_{ij}), the elasticity of substitution (σ), and the outward and inward "multilateral resistances" of each country (Π_i and P_j, respectively). The outward multilateral resistance (OMR) and inward multilateral resistance (IMR) terms are defined by equations (OMR) and (IMR), respectively. These terms represent the aggregate trade costs faced by the exporting and importing countries and connect the bilateral trade between countries *i* and *j* with the rest of the world.

[541] Yotov et al., "An Advanced Guide," 2016.
[542] Anderson and van Wincoop, "Gravity with Gravitas," 2003. For details on the broad range of models that yield this same gravity system, see Arkolakis, Costinot, and Rodríguez-Clare, "New Trade Models, Same Old Gains?" 2012.

As countries adjust policies or other factors that affect trade costs, the multilateral resistance terms of the rest of the world are impacted. For example, these terms capture the idea that if two countries become more open to one another, they become relatively more distant to the rest of the world and trade creation and diversion naturally follow. This complex set of relationships is one of the principal motivations for using this simulation model to analyze the effects of policies on trade. The empirical model described in the previous section (Empirical) represents just one equation—(Gravity) — in the full structural model. . Importantly, that empirical model controls for IMR and OMR terms using country-year fixed effects, but it does not capture the relationship between those terms and the trade policies, as they are also absorbed in the country-year fixed effects. Thus, it is not able to determine how changes in MRL policies affect the multilateral resistance terms, which themselves are integral in understanding trade flows.

Together, equations (Gravity), (OMR), and (IMR) describe the canonical gravity model. However, in addition to these standard relationships, two additional pieces are included. Equation (Prices) introduces a relationship between the IMR term and the factory gate prices (p_i) received by producers. This equation also links prices to the value of local output (Y_i) and an exogeneous preference parameter (α_i). Finally, equation (Expenditure) determines expenditure in each country. The model is an endowment economy, meaning that the quantity of output (Q_i) is fixed for each country. Expenditure is set as a fixed ratio (ϕ_i) of the value of output in each country.

To evaluate the effects of changes in MRL trade policies using the simulation model, four steps were undertaken.

1. **Estimate Trade Costs:** One of the most important components of the simulation model are the bilateral trade costs (t_{ij}) because they are the terms that capture the trade policies of interest in the analysis. A measure of the trade costs was estimated using the empirical gravity model depicted in equation (Empirical). The gravity variables, which serve as trade cost proxies, were multiplied by their respective coefficient estimates and summed together, thereby providing an econometrically estimated measure of bilateral trade costs.
2. **Solve Baseline Model:** Using the econometrically estimated trade costs in conjunction with observed data for output and expenditures and an exogenous elasticity of substitution, a baseline version of the model was solved. This baseline model finds the OMR, IMR, and other parameter values that solve the system of equations given the supplied information.
3. **Compute Counterfactual Trade Costs:** To analyze the effects of a change in MRLs, the trade costs were modified to reflect a counterfactual scenario in which EU MRLs were 90 percent lower. The same coefficient estimates derived in step 1 were combined with modified trade cost variables to produce counterfactual bilateral trade costs. Specifically, the two MRL indexes were adjusted to reflect the intended scenario. For some country pairs, trade costs increased; for others they decreased.
4. **Solve the Counterfactual Model:** Finally, the model was re-solved using the altered trade costs. This generated a new set of OMR and IMR terms, new prices, new values for expenditures and output, and new values of bilateral trade between each country. To produce many of the results of interest, the counterfactual values for each of these components were compared to the baseline values to determine the percentage change between the two and other measures of interest.

This four-step process was undertaken for each of three crop groups: tropical fruit, temperate fruit, and fresh and dried beans and peas. While the empirical model described in the previous section used highly disaggregated crop groups, the simulation model used more aggregated sectors in order to aid the computational feasibility of the analysis.[543] Additional econometric estimates were derived using the aggregate crop groups. The underlying crops in each aggregate group were pooled together and the country-year fixed effects were replaced with country-year-sector fixed effects to better control for sectoral heterogeneity. The coefficients on the trade cost variables were treated as common to all crops, implying that the derived estimates reflect an average across all crops within the aggregate group. The gravity estimates for those three simulations are presented in table F.2–F.4. All three crop groups yielded typical gravity estimates for the non-MRL variables. The only notable exception was the negative estimate for joint EU membership for tropical fruit. However, given the climate requirements of tropical fruit production, it is not surprising that trade within the European Union is small relative to other trading relationships.

Because the counterfactual scenario examined changes in MRL policies, the estimates of the two MRL terms were critical for determining the outcomes of the model. The MRL heterogeneity term was negative in all three sectors, implying that regulatory heterogeneity increased bilateral trade costs in all of the simulations. The MRL stringency estimates were positive for temperate fruit and fresh and dried beans and peas, implying that lower MRLs increased trade costs with all international exporters. However, the stringency term was negative for tropical fruit, implying that lower MRLs reduced trade costs with foreign exporters in that market.

Table F.2 Gravity estimates for tropical fruit

Note: The asterisks (stars) that are attached to estimate values report the statistical significance of the estimates: *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.10$, where p denotes the probability that the true value is equal to zero (i.e., that the measure has no impact on bilateral trade). Superscripts labeled 1 indicate $p >= 0.1$. Exporter-year and importer-year fixed effects were included but not reported.

Variable	Estimate	Statistical significance	Standard error
International	-3.470	***	0.195
Distance	-1.291	***	0.092
Contiguity	1.370	***	0.102
Language	0.110	1	0.106
PTA	0.445	***	0.107
EU membership	-1.033	***	0.383
Colony	0.211	1	0.150
MRL heterogeneity	-0.252	***	0.039
MRL stringency	-0.260	***	0.075

Source: USITC estimates.

[543] The aggregate crop groups were derived from the original crop groups based on the following categorization. Tropical fruit includes avocados; bananas; cashew apple; cocoa beans; coconuts; green coffee; dates; figs; tropical fresh fruit not elsewhere specified (n.e.s.); grapefruit (including pomelos); kiwi fruit; lemons and limes; mangoes, mangosteens, and guavas; papayas; pineapples; plantains and others; and tangerines, mandarins, clementines, and satsumas. Temperate fruit includes apples; apricots; blueberries; cherries; currants; peaches and nectarines; pears; persimmons; and plums and sloes. Beans and peas includes all beans and all peas.

Table F.3 Gravity estimates for temperate fruit

Note: The asterisks (stars) that are attached to estimate values report the statistical significance of the estimates: *** indicates p < 0.01, ** indicates p < 0.05, and * indicates p < 0.10, where p denotes the probability that the true value is equal to zero (i.e., that the measure has no impact on bilateral trade). Exporter-year and importer-year fixed effects were included but not reported.

Variable	Estimate	Statistical significance	Standard error
International	-4.400	***	0.176
Distance	-1.240	***	0.058
Contiguity	0.559	***	0.091
Language	0.438	***	0.072
PTA	1.704	***	0.085
EU membership	0.536	***	0.127
Colony	1.672	***	0.167
MRL heterogeneity	-0.076	*	0.042
MRL stringency	0.125	***	0.034

Source: USITC Estimates.

Table F.4 Gravity estimates for fresh and dried beans and peas

Note: The asterisks (stars) that are attached to estimate values report the statistical significance of the estimates: *** indicates p < 0.01, ** indicates p < 0.05, and * indicates p < 0.10 where p denotes the probability that the true value is equal to zero (i.e., that the measure has no impact on bilateral trade). Exporter-year and importer-year fixed effects were included but not reported.

Variable	Estimate	Statistical significance	Standard error
International	-2.541	***	0.215
Distance	-1.633	***	0.098
Contiguity	0.438	***	0.129
Language	0.629	***	0.100
PTA	0.207	*	0.118
EU membership	0.732	***	0.238
Colony	0.816	***	0.230
MRL heterogeneity	-0.219	***	0.052
MRL stringency	0.409	***	0.083

Source: USITC estimates.

In addition to the trade costs, the baseline simulations were supplied with some additional information in order to fully parameterize the model. Measures of total output and expenditures were derived from the trade and production values of each individual crop within the aggregate groups. The simulations' baselines were based on trade and production in 2016, which was the latest year for which the necessary data were available. An elasticity of substitution of 8 was used for all crop groups. This value was based on the estimate derived for agriculture by Caliendo and Parro (2015).[544] Values for the expenditure share (ψ_i) and consumer preference (α_i) parameters were calibrated to the baseline model. Baseline prices were normalized to 1.

[544] Caliendo and Parro, "Estimates of the Trade and Welfare Effects of NAFTA," 2015.

The OMR and IMR terms in the simulation gravity model are not uniquely determined. To solve the model, a reference importer must be selected and its IMR fixed at 1, thereby pinning a unique solution. As a consequence, all other IMRs and OMRs are solved relative to this reference importer. The simulations use South Africa as the reference importer for tropical and temperate fruit. South Africa was chosen because it was a relatively large trader of the crops, was not a country of significant interest in the analysis, and was not particularly affected by the policy scenario. The model for fresh and dried beans and peas used the United States because South Africa was not a significant trader of those crops.

Full Simulation Results

The following tables depict the full results for each simulation model. These results report the estimated outcomes for the complete set of countries in each model. The countries included in each model represent the intersection of (a) countries that are major producers or consumers of the crops, representing 99 percent of global commerce in each crop, and (b) countries that had MRL information published in the Homologa database.

Table F.5 Simulated effects of lowering EU MRLs by 90 percent on tropical fruit

	Factory gate price change (percent)	Consumer price change (percent)	Terms of trade change (percent)	Exports change (percent)	Imports change (percent)	Exports change (1,000 $)	Imports change (1,000 $)
Argentina	-0.53	-0.38	-0.15	-1.75	-3.72	-4,770	-4,111
Australia	0.09	0.09	0.00	-0.84	0.04	-619	79
Brazil	0.06	0.06	0.00	-0.68	0.16	-28,455	60
Canada	0.11	0.12	-0.01	-0.88	0.13	-441	1,921
Switzerland	-0.53	0.13	-0.66	-17.81	-0.76	-3,784	-3,747
Chile	0.17	0.15	0.01	-0.50	1.95	-3,257	909
China	0.09	0.09	0.00	-0.35	0.02	-3,286	219
Colombia	0.20	0.20	0.00	-0.20	1.25	-5,633	91
Germany	-1.86	-2.06	0.20	22.62	-1.38	184,133	-41,452
Egypt	0.79	0.83	-0.03	-3.30	-1.97	-1,716	-1,267
Spain	1.71	1.32	0.38	3.14	28.65	67,711	298,130
France	-0.40	-1.96	1.60	14.08	1.67	41,885	24,030
United Kingdom	-1.95	-2.07	0.13	28.15	-1.83	31,900	-25,006
Greece	-0.49	-1.26	0.77	15.12	2.05	10,962	3,466
Indonesia	0.15	0.15	0.00	-0.11	0.44	-1,217	824
India	0.12	0.12	0.00	-0.08	0.59	-315	665
Israel	0.03	0.03	0.00	-0.70	-0.30	-2,254	-136
Italy	-1.34	-1.76	0.42	18.80	0.84	96,330	13,432
Japan	0.13	0.13	0.00	-2.34	0.16	-84	3,269
South Korea	0.11	0.11	0.00	-0.82	0.13	-53	856
Morocco	-1.17	-1.10	-0.07	-3.10	-7.64	-10,714	-5,092
Mexico	0.13	0.13	0.00	0.01	0.61	495	878
Malaysia	0.12	0.13	-0.01	-0.61	0.10	-503	488
Philippines	0.33	0.33	0.00	0.17	2.06	2,076	2,992
Poland	-1.42	-2.10	0.69	24.93	-1.42	3,198	-7,868
Russia	-0.06	-0.07	0.01	-0.07	-0.04	-1	-469
Thailand	0.13	0.13	0.00	-0.14	0.26	-1,239	935
Turkey	-2.20	-1.96	-0.25	-6.26	-15.50	-24,098	-19,634
United States	0.09	0.09	0.00	-0.39	0.12	-3,708	8,248
Vietnam	0.10	0.10	0.00	-0.08	-0.02	-2,082	-65
South Africa	0.00	0.00	0.00	-1.00	0.35	-3,791	161

Source: USITC estimates.
Note: Corresponds to figure 3.1.

Table F.6 Simulated effects of lowering EU MRLs by 90 percent on temperate fruit

	Factory gate price change (percent)	Consumer price change (percent)	Terms of trade change (percent)	Exports change (percent)	Imports change (percent)	Exports change (1,000 $)	Imports change (1,000 $)
Argentina	-0.18	-0.18	0.00	-0.22	-0.38	-1,070	-18
Australia	-0.16	-0.16	0.00	-0.22	-0.32	-90	-91
Austria	2.28	3.08	-0.77	-7.17	-2.99	-11,031	-6,490
Belgium	1.70	2.42	-0.71	-3.69	-8.98	-11,762	-25,146
Brazil	-0.18	-0.18	0.00	-0.04	-0.43	-5	-1,584
Canada	-0.16	-0.16	0.00	-0.11	-0.39	-214	-3,039

	Factory gate price change (percent)	Consumer price change (percent)	Terms of trade change (percent)	Exports change (percent)	Imports change (percent)	Exports change (1,000 $)	Imports change (1,000 $)
Switzerland	0.25	0.53	-0.28	-3.49	-1.15	-58	-1,869
Chile	-0.19	-0.19	0.00	0.12	-0.51	2,535	-25
China	-0.15	-0.15	0.00	-0.25	-0.26	-2,400	-2,420
Germany	3.70	3.93	-0.22	-17.44	3.75	-41,627	61,415
Denmark	3.29	3.90	-0.58	-10.95	3.19	-1,399	3,702
Egypt	0.44	0.51	-0.06	-2.04	-0.37	-50	-436
Spain	0.34	0.50	-0.16	1.51	-20.93	23,605	-70,570
France	1.70	2.28	-0.57	-4.59	-6.85	-28,744	-39,738
United Kingdom	3.56	3.70	-0.14	-15.05	3.52	-850	29,418
Greece	1.32	1.63	-0.30	-4.45	-12.37	-5,123	-2,338
Hungary	1.90	2.86	-0.93	-6.88	-5.84	-1,314	-1,645
Indonesia	-0.16	-0.16	0.00	-0.28	-0.38	0	-1,121
India	-0.18	-0.18	0.00	0.24	-0.19	0	-512
Israel	-0.10	-0.10	0.00	0.78	0.09	83	39
Italy	0.86	1.16	-0.30	-0.55	-16.46	-6,272	-52,404
Japan	-0.15	-0.14	0.00	-0.40	-0.43	-370	-204
South Korea	-0.13	-0.13	0.00	-0.49	-0.47	-328	-567
Morocco	-0.36	-0.21	-0.15	-2.16	-4.11	-1,472	-801
Mexico	-0.17	-0.18	0.01	0.15	-0.30	241	-1,132
Netherlands	1.35	1.66	-0.30	-0.69	-13.61	-4,771	-73,610
Norway	0.29	0.46	-0.17	-2.30	0.47	-22	549
Poland	2.10	2.61	-0.50	-5.34	-6.16	-8,560	-10,484
Portugal	1.69	2.13	-0.44	-6.18	-6.73	-7,519	-8,943
Romania	2.44	2.75	-0.30	-9.17	-4.44	-674	-4,336
Russia	-0.11	-0.11	0.00	0.27	-0.05	15	-174
Sweden	3.31	3.83	-0.50	-13.11	3.40	-1,697	5,722
Turkey	-0.35	-0.30	-0.05	-1.59	-5.96	-3,423	-540
Taiwan	-0.15	-0.15	0.00	-0.34	-0.34	-13	-1,294
Ukraine	-0.04	0.03	-0.07	-0.56	-0.07	-15	-28
United States	-0.17	-0.17	0.00	-0.25	-0.31	-4,089	-4,051
Vietnam	-0.15	-0.15	0.00	-0.40	-0.35	0	-1,530
South Africa	0.00	0.00	0.00	1.93	1.36	7,562	58

Source: USITC estimates.
Note: Corresponds to figure 3.1.

Table F.7 Simulated effects of lowering EU MRLs by 90 percent on fresh and dried beans and peas

	Factory gate price change (percent)	Consumer price change (percent)	Terms of trade change (percent)	Exports change (percent)	Imports change (percent)	Exports change (1,000 $)	Imports change (1,000 $)
Argentina	0.05	0.05	0.00	-0.10	-0.17	-317	-3
Belgium	4.46	4.53	-0.07	-7.85	4.06	-3,688	5,322
Brazil	0.05	0.05	0.00	0.94	-0.11	142	-322
Canada	-0.02	-0.02	0.00	0.37	-0.68	4,555	-1,278
Switzerland	0.79	1.24	-0.44	-8.18	-0.49	-23	-81
Chile	0.04	0.04	0.00	0.02	-0.29	1	-33
China	0.01	0.01	0.00	-0.16	-0.08	-881	-282
Colombia	0.04	0.04	0.00	0.73	-0.10	8	-34
Germany	3.99	4.24	-0.24	-3.46	1.67	-1,723	1,632
Egypt	0.49	0.54	-0.05	0.02	-7.71	12	-1,557
Spain	3.56	3.70	-0.13	-1.00	-1.10	-638	-851
France	2.74	3.20	-0.44	3.97	-7.08	8,816	-7,035
United Kingdom	4.32	4.39	-0.06	-4.84	3.56	-1,424	5,682
Greece	3.69	3.85	-0.15	-4.52	-0.95	-46	-147
Hungary	2.94	3.15	-0.20	0.25	-5.39	76	-1,281
Indonesia	0.01	0.01	0.00	-0.21	-0.20	-38	-15
India	0.00	0.00	0.00	0.61	-0.20	147	-2,068
Israel	0.22	0.22	0.00	0.73	0.33	1	32
Italy	4.28	4.41	-0.12	-7.41	3.96	-1,512	7,066
Japan	0.04	0.04	0.00	-0.37	-0.26	-1	-434
South Korea	0.03	0.03	0.00	-0.32	-0.28	0	-141
Lithuania	2.49	2.51	-0.02	4.59	-8.70	3,355	-177
Mexico	0.08	0.07	0.01	0.76	0.28	1,025	402
Netherlands	3.03	3.25	-0.21	3.44	-8.15	4,362	-7,941
Philippines	0.02	0.01	0.00	-0.11	-0.24	0	-73
Portugal	4.30	4.49	-0.18	-6.80	3.98	-527	1,289
Romania	3.13	3.27	-0.14	-1.15	-3.36	-202	-414
Russia	0.08	0.07	0.02	0.48	1.28	769	162
Sweden	3.74	3.95	-0.20	-2.34	1.26	-94	172
Thailand	0.01	0.01	0.00	-0.27	-0.22	-87	-28
Turkey	0.42	0.45	-0.03	-6.44	-0.56	-458	-650
Ukraine	0.17	0.14	0.03	1.46	3.12	953	38
Vietnam	0.01	0.01	0.00	-0.19	-0.26	-1	-271
United States	0.01	0.00	0.01	0.19	-0.24	1,003	-760

Source: USITC estimates.
Note: Corresponds to figure 3.1.

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Appendix G
Technical Appendix: Supply Response and Farm Income Statement Analyses

Technical Appendix: Supply Response and Farm Income Statement Analyses

This appendix describes the technical details and inputs used in the supply response analysis and the farm income statement analysis.

Supply Response Analysis

The supply response analysis measures the impact of low and missing MRLs on one component of agricultural output in two industries: the Costa Rican banana industry and the U.S. tart cherry industry. Specifically, this analysis measures the effect of changes in farm gate prices caused by changes in MRLs on agricultural industries' willingness to supply these products.

The analysis assumes that the Costa Rican banana industry and the U.S. tart cherry industry do not affect global prices. However, farms in these industries respond to global price changes over the long term by adjusting their planting and harvesting decisions. That is, price changes lead to changes in quantity supplied based on the price elasticity of supply in each country. Price changes are multiplied by the price elasticity of supply in order to calculate the change in quantity caused by these price changes. Sources of price, price elasticity of supply, and production inputs are described in table G.1, and the methodology, limitations, and analysis are described in greater detail within chapter 4.

Table G.1 Sources for inputs used in analyzing the supply response of changes in MRLs: bananas from Costa Rica and tart cherries from the United States

Note: mt = metric tons

Parameter	Bananas from Costa Rica	Tart cherries from the United States
Baseline production (mt)	FAOSTAT database, 2018 annual production, Costa Rica bananas	FAOSTAT database, 2018 annual production, United States sour cherries
Price change (percent)	Price shock 1: Simulation gravity model results (Colombia, tropical fruit) Price shock 2: Approximated for illustrative purposes at −5 percent	Price shock 1: Simulation gravity model results (United States, temperate fruit) Price shock 2: Approximated for illustrative purposes at −5percent
Price elasticity of supply	Average of two elasticities: 1. Estimate of banana export supply elasticity of 0.5 for Costa Rica from 1985 to 2000. Arias et al., "The World Banana Economy, 1985–2002," 2003. 2. Estimate of banana supply elasticity of 1.4 for Caribbean countries. NERA Economic Consulting and Oxford Policy Management, *Addressing the Impact of Preference Erosion in Bananas*, 2004.	Average of two elasticities: 1. A supply elasticity of 0.2 used for production of apples (another tree fruit). Busdieker, "Welfare Effects of New Fire Blight Control Methods," 2011. 2. A supply elasticity of 0.75 used for perennial crops. Jetter, Chalfant, and Sumner, "An Analysis of the Costs and Benefits," April 2004.
Production change (percent)	$(Price\ elasticity\ of\ supply)(Price\ change) = (Production\ change)$	
New production (mt)	$(Baseline\ production)(1 + Production\ change) = (New\ production)$	

Source: USITC estimates.

Farm Income Statement Analysis

In the farm income statement analysis, income statements are produced using a variety of inputs that approximate the costs, prices, yields, acreage, and income of typical farms in the Costa Rican banana and U.S. tart cherry industries. Data for these approximations are from publicly available reports provided by governments and agricultural extension services, as well as information derived from case study research and fieldwork conducted by Commission staff (tables G.2 and G.3). Various shocks derived from case study analysis are then applied directly in these farms' income statements in various "scenarios." Each of these shocks, and the method by which they're applied, are described below.

Table G.2 Sources for inputs used in farm income statement analysis: Siquirres Banana Farm
Note: mt = metric tons; ha = hectares

Indicator	Baseline amount	Baseline source	Baseline explanation	Scenario effects
H Farm size (ha)	900	Approximated	Costa Rican banana farms are frequently over 250 acres (volume 1 case study). 900 hectares was used to represent a large banana-growing operation.	Fixed.
Y Yield (mt/ha)	49.2	Government of Costa Rica, MAG, SEPSA, *Boletín Estadístico Agropecuario*, April 2020, 30.	This is the average yield per hectare in the Siquirres region.	Scenario 1: Reduced by 57.4 percent, reflecting compounded effects of nematode (reduces yield by 41percent) and insect damage (reduces yield by 21.8percent). $Y_1 = (1 - 0.574)Y$ Scenario 2: Reduced by 6.3 percent, reflecting effects of alternative fungicide use for treating black sigatoka fungus. $Y_2 = (1 - 0.063)Y$
Q Production (mt)	44,280	Calculated based on other inputs.	$Q = HY$	Adjusts in response to yield effects. $Q_n = HY_n$
Q_{ALL} Shipments (mt)	44,280	Calculated based on other inputs.	Assumes that the farm maintains MRL levels within EU limits and therefore continues to participate in the global market, such that differentiation by shipment destination is unnecessary. $Q_{ALL} = Q$	Shipments adjust with production. $Q_{ALLn} = Q_n$
P Producer price ($/mt)	453.00	FAO, FAOSTAT database (accessed August 12, 2020).	This is the 2018 producer price (USD) for bananas from Costa Rica.	Fixed.
R Revenue ($)	20,058,840	Calculated based on other inputs.	$R = PQ$	Adjusts with changes in production. $R_n = PQ_n$
C_V Variable Costs ($) *Component costs (not included in chapter)* **C_L** Labor costs ($) **$C_S$** Supply costs ($)	10,095,712	Chacón and Espinoza, “Modelo de Costos de Producción, Plátano” (production cost model, bananas), 2019. From the per-hectare farm budget: Labor costs = C_{LB} Supply costs = C_{SB} Farm budget yield = Y_B	Assumes that all labor and supply costs are variable costs. Because the Siquirres Banana Farm is expected to have much higher yield than the per-hectare farm budget, the cost of operations is also higher. $C_L = H\left(\frac{Y}{Y_B}\right)(C_{LB})$ $C_S = H\left(\frac{Y}{Y_B}\right)(C_{SB})$ $C_V = C_L + C_S$	Scenario 1: Labor costs associated with application of nematocides and insecticides removed; supply cost reduced by 50 percent. $C_{L1} = H\left(\frac{Y}{Y_B}\right)(C_{LB} - 118)$ $C_{S1} = 0.5C_S$ $C_{V1} = C_{L1} + C_{S1}$ Scenario 2: Variable costs increase overall by 3.5 percent due to the more expensive fungicide needed to treat black sigatoka fungus. $C_{V2} = 1.035C_V$

Indicator	Baseline amount	Baseline source	Baseline explanation	Scenario effects
C_F Fixed costs ($)	3,228,038	Chacón and Espinoza, "Modelo de Costos de Producción, Plátano" (production cost model, bananas), 2019. From the per-hectare farm budget: Other costs = C_{OB} Establishment costs = C_{EB} Farm budget yield = Y_B	Assumes that farm establishment costs are spread over 10 years; all other costs are fixed costs. Because the Siquirres Banana Farm is expected to have much higher yield than the per-hectare budget, the cost of operations is also higher. $C_F = H\left(C_{OB} + \frac{C_{EB}}{10}\right)(\frac{Y}{Y_B})$	Fixed.
C Total costs ($)	13,323,749	Calculated based on other inputs.	$C = C_V + C_F$	Adjusts with changes in variable costs. $C_n = C_{Vn} + C_{Fn}$
U_V Variable unit costs ($/mt)	228	Calculated based on other inputs.	$U_V = C_V/Q$	Adjusts with changes in variable costs and output. $U_{Vn} = C_{Vn}/Q_n$
U_F Fixed unit costs ($/mt)	73	Calculated based on other inputs.	$U_F = C_F/Q$	Adjusts with changes in variable costs and output. $U_{Fn} = C_{Fn}/Q_n$
U Total unit costs ($/mt)	301	Calculated based on other inputs.	$U = C/Q$	Adjusts with changes in variable costs and output. $U_n = C_n/Q_n$
I Operating income ($)	6,735,091	Calculated based on other inputs.	$I = R - C$	Adjusts with changes in revenues and total costs. $I_n = R_n - C_n$
%I Operating income (%)	33.6	Calculated based on other inputs.	$\%I = I/R$	Adjusts with changes in revenues and operating income. $\%I_n = I_n/R_n$

Source: USITC estimates.

Table G.3 Sources for inputs used in farm income statement analysis: Michigan Tart Cherry Farm

Note: mt = metric tons; IQF = individually quick frozen

Indicator	Baseline amount	Baseline source	Baseline explanation	Scenario effects
H Farm size (acres)	100	Approximated	U.S. tart cherry farms can be hundreds of acres in size, based on public sources for individual farms.	Fixed.
Y Yield (pounds/acre)	8,000	Penn State Extension, "Mature Tart Cherry Production Orchard Budget," 2020.	The farm budget was used as the foundation for yield in this analysis. Yields fluctuate significantly from year to year.	Fixed. Note that although several scenarios require changes in pesticide use, there is no indication from the case study that this change has yield-reducing effects.
Q Production (pounds)	800,000	Calculated based on other inputs.	$Q = HY$	Fixed. Because farm size and yield remain fixed, this is also fixed.

Indicator	Baseline amount	Baseline source	Baseline explanation	Scenario effects
Q_{EU} EU exports (pounds)	80,000	Approximation based on other inputs; volume 2 case study.	The case study refers to an EU shipment that forms the basis of several scenarios. According to the case study, about 10 percent of the U.S. tart cherry crop is exported. Therefore, 10 percent is a reasonable approximation of a major EU shipment for an individual farm. $Q_{EU} = 0.1Q$	Scenario 1: Fixed. $Q_{EU1} = 0.1Q_1$ Scenario 2–3: Proportion sold to the EU is reduced to 0 percent, as production is noncompliant with EU MRL. $Q_{EUn} = 0Q_n$ Scenario 4: Proportion sold to the EU is increased to 50 percent. $Q_{EU4} = 0.5Q_4$
Q_X Non-EU exports (pounds)	0	Approximated based on other inputs; volume 2 case study.	In the baseline, it is assumed that all exports go to the EU shipment in question, and none go to non-EU partners. $Q_X = 0Q$	Scenarios 1, 3–4: Fixed at baseline levels. $Q_{NonEUn} = 0Q_n$ Scenario 2: Proportion exported to non-EU buyers increases to 10 percent following shift in EU shipment to non-EU buyers. $Q_{X2} = 0.1Q_2$
Q_D Domestic shipments (pounds)	720,000	Calculated based on other inputs.	The remaining production is sold to the U.S. domestic market. $Q_D = Q - (Q_{EU} + Q_X)$	Adjusts with changes in export shipments. $Q_{Dn} = Q - (Q_{EUn} + Q_{Xn})$
P Producer price ($/pound) *Component prices (not included in chapter)* **P_{EU}** EU price ($/pound) **$P_X$** Non-EU price ($/pound) **P_D** Domestic price ($/pound)	0.24	Approximated based on volume 2 case study. From the case study: Processed IQF price for EU sale = P_{EUF} = $0.84 Processed IQF price for non-EU sale = P_{XF} = $0.14 Domestic farm gate price = P_D = $0.22	The domestic farm gate price is the price returned to the farmer for domestic shipments. The foreign IQF prices include a prepaid processing fee that is unspecified in the case study. Tart cherry processing adds significant value, so a prepaid processing fee (F) of $0.45/pound is used in order to capture a cost structure consistent with relatively narrow profit margins. $P_{EU} = P_{EUF} - F$ $P_X = P_{XF} - F$ $P = \frac{P_{EU}Q_{EU} + P_X Q_X + P_D Q_D}{Q}$	Component prices remain constant throughout scenarios, but their representation within the overall producer price fluctuates based on exports. $P_n = \frac{P_{EUn}Q_{EUn} + P_{Xn}Q_{Xn} + P_{Dn}Q_{Dn}}{Q}$
R Revenue ($)	189,600	Calculated based on other inputs.	$R = PQ$	Adjusts with changes in production. $R_n = PQ_n$

Indicator	Baseline amount	Baseline source	Baseline explanation	Scenario effects
C_V Variable costs ($)	158,200	Industry representative, telephone interview by USITC staff, July 8, 2020; Penn State Extension, “Mature Tart Cherry Production Orchard Budget,” 2020.	Variable costs are derived from per-acre farm budget, multiplied by 100 acres, and adding in $500 in testing fees applied to total variable costs. Although a given shipment may be tested multiple times, it is assumed that this farm is one of multiple farms providing tart cherries for this shipment.	Scenarios 1 and 4: Adds per-acre additional cost of $130 per acre to account for EU removal of fenpropathrin and use of alternative production practices (see case study). $C_n = C + 13{,}000$ Scenario 2: In addition to additional cost of $130 per acre (described above), adds storage cost of $6,000 to account for rejected shipment and need to find alternative buyer. This figure was considered consistent with a large unexpected cost for 80,000 pounds of frozen cherries. $C_2 = C + 13{,}000 + 6{,}000$ Scenario 3: Farm foregoes EU sales, so saves on testing fees ($500) and avoids other additional costs. $C_3 = C - 500$
C_F Fixed costs ($)	30,602	Penn State Extension, “Mature Tart Cherry Production Orchard Budget,” 2020.	Fixed costs are derived directly from the per-acre farm budget, multiplied by 100 acres.	Fixed.
C Total costs ($)	188,802	Calculated based on other inputs.	$C = C_V + C_F$	Adjusts with changes in variable costs. $C_n = C_{Vn} + C_{Fn}$
U_V Variable unit costs ($/pound)	0.20	Calculated based on other inputs.	$U_V = C_V/Q$	Adjusts with changes in variable costs and output. $U_{Vn} = C_{Vn}/Q_n$
U_F Fixed unit costs ($/pound)	0.04	Calculated based on other inputs.	$U_F = C_F/Q$	Adjusts with changes in variable costs and output. $U_{Fn} = C_{Fn}/Q_n$
U Total unit costs ($/pound)	0.24	Calculated based on other inputs.	$U = C/Q$	Adjusts with changes in variable costs and output. $U_n = C_n/Q_n$
I Operating income ($)	798	Calculated based on other inputs.	$I = R - C$	Adjusts with changes in revenues and total costs. $I_n = R_n - C_n$
%I Operating income (%)	0.4	Calculated based on other inputs.	$\%I = I/R$	Adjusts with changes in revenues and operating income. $\%I_n = I_n/R_n$

Source: USITC estimates.

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Appendix H
Data Tables for Figures

Table H.1 Total U.S. crop exports: Specialty crops and other edible crop products, 2016–19 (billion dollars) for figure 1.1

Year	U.S. specialty crop exports (billions $)	All other U.S. crop exports (billions $)
2016	26.6	62.5
2017	27.2	61.5
2018	27.0	59.3
2019	27.3	57.1

Source: USITC, *Shifts in U.S. Merchandise Trade Dataset*. Total crop exports represent agricultural (AG) products sectors in USITC digests 017–042. These USITC digest sectors encompass a number of related 8-digit subheadings in the Harmonized Tariff Schedule of the United States (HTS), which classifies tradable goods. The sectors are listed and defined in USITC, "Frequently Asked Questions," Shifts in U.S. Merchandise Trade 2015, September 2016. Specialty crops include AG digests 017–029, 037, and 038, and include fruits, vegetables, nuts, cocoa, tea, spices, coffee, and tea. Other edible crop products are captured in AG digests 030–036 and 039–042 and include products such as alcoholic beverages, grains, oilseeds, animal or vegetable fats and oils, and processed products such as pasta, baked goods, infant formula, sauces, soups, and condiments.
Note: Correspond to figure 1.1.

Table H.2 U.S. specialty crop exports by major export market, 2019 (billion dollars) for figure 1.2

U.S. export market	U.S. specialty crop exports (billions $)
Canada	7.69
Mexico	2.29
European Union	4.60
Japan	1.77
South Korea	1.20
China	1.12
Taiwan	0.60
All other	8.00

Source: USITC, *Shifts in U.S. Merchandise Trade Dataset*. Total crop exports represent agricultural (AG) products sectors in USITC digests 017–042. These USITC digest sectors encompass a number of related 8-digit subheadings in the Harmonized Tariff Schedule of the United States (HTS), which classifies tradable goods. The sectors are listed and defined in USITC, "Frequently Asked Questions," Shifts in U.S. Merchandise Trade 2015, September 2016. Specialty crops include AG digests 017–029, 037, and 038, and include fruits, vegetables, nuts, cocoa, tea, spices, coffee, and tea. Other edible crop products are captured in AG digests 030–036 and 039–042 and include products such as alcoholic beverages, grains, oilseeds, animal or vegetable fats and oils, and processed products such as pasta, baked goods, infant formula, sauces, soups, and condiments.
Note: Correspond to figure 1.2.

Table H.3 U.S. exports of apples and pears to the European Union, 2012–19 (million dollars) for figure 2.1

Year	U.S. apple exports (million $)	U.S. pear exports (million $)
2012	18.5	2.4
2013	20.1	1.7
2014	13.3	0.5
2015	8.4	0.5
2016	6.4	0.0
2017	4.6	0.2
2018	8.2	0.0
2019	2.2	0.0

Source: Source: USITC/USDOC DataWeb, HTS 0808.10 (accessed July 27, 2020).
Note: Correspond to figure 2.1.

Table H.4 U.S. exports of apples and pears to major markets, 2012–19 (million dollars) for figure 2.2

	Mexico	Canada	Taiwan	Vietnam	European Union	All others
2012	373.9	251.0	86.8	16.9	20.9	532.4
2013	426.8	268.6	85.8	33.6	21.9	486.5
2014	367.5	256.8	93.3	54.2	13.8	506.0
2015	358.4	223.0	80.1	37.2	8.9	497.7
2016	309.5	245.5	76.6	36.2	6.4	407.5
2017	346.0	213.7	77.6	34.9	4.8	441.7
2018	366.0	202.6	59.8	51.1	8.2	474.7
2019	357.2	204.7	101.4	70.3	2.3	382.1

Source: Source: USITC/USDOC DataWeb, HTS 0808.10 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.2.

Table H.5 U.S. exports of celery to major markets, 2016–19 (million dollars) for figure 2.3

	Canada	Japan	Hong Kong	Taiwan	All other
2016	66.1	5.9	4.0	5.9	7.7
2017	68.4	4.4	3.6	4.0	6.5
2018	65.4	4.9	3.2	3.8	6.6
2019	101.1	4.3	3.1	2.8	4.9

Source: USITC/USDOC DataWeb, HS 0709.40 (accessed July 27, 2020).
Note: Correspond to figure 2.3.

Table H.6 U.S. exports of chickpeas and lentils to major markets, 2016–19 (million dollars) for figure 2.4

	Canada	Mexico	India	European Union	All other
2016	134.0	138.0	166.4	161.9	408.6
2017	158.2	149.1	68.8	210.1	438.8
2018	93.3	119.2	16.8	162.3	292.8
2019	143.4	102.4	42.6	157.5	320.8

Source: USITC/USDOC DataWeb, HS 0713 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period.Correspond to figure 2.4.

Table H.7 U.S. exports of dried cranberries to major markets, 2016–19 (million dollars) for figure 2.5

	European Union	China	Canada	Mexico	Malaysia	All other
2016	75.6	26.1	27.6	26.7	1.2	70.4
2017	86.2	45.5	26.2	29.9	2.8	74.4
2018	93.3	54.7	26.0	32.1	5.8	84.9
2019	95.6	38.5	28.2	28.0	19.6	83.2

Source: USITC/USDOC DataWeb, HTS 2008.93 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.5.

Table H.8 U.S. exports of cranberry juice to major markets, 2016–19 (million dollars) for figure 2.6

	Mexico	European Union	Canada	Jamaica	Bahamas	All other
2016	3.9	39.7	7.2	0.4	0.2	8.4
2017	4.1	41.1	7.6	0.9	1.1	8.7
2018	5.4	23.7	7.8	1.2	1.1	9.3
2019	11.6	5.7	5.5	2.0	1.4	8.6

Source: USITC/USDOC DataWeb, HTS 2009.81 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.6.

Table H.9 U.S. exports of fresh sweet cherries to major markets, 2016–19 (million dollars) for figure 2.7

	Canada	South Korea	China	Taiwan	European Union	All other
2016	105.9	104.9	73.0	39.6	4.3	8.4
2017	136.8	133.6	121.6	54.9	8.4	8.7
2018	118.5	126.6	81.8	49.1	5.4	9.3
2019	120.6	99.4	71.4	49.4	3.3	8.6

Source: USITC/USDOC DataWeb, HTS 0809.29 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.7.

Table H.10 U.S. exports of fresh, frozen, dried, and preserved tart cherries to major markets, 2016–19 (million dollars) For figure 2.8

	Canada	China	Japan	European Union	All other
2016	13.5	2.2	1.8	4.3	25.4
2017	13.8	1.8	2.1	7.2	42.1
2018	16.7	9.6	3.4	6.0	12.1
2019	16.1	4.1	3.1	3.0	16.2

Source: USITC/USDOC DataWeb, Schedule B 0813403010, 0811908060, 2008600060, 0809210000 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.8.

Table H.11 U.S. exports of sweet potatoes to major markets, 2016–19 (million dollars) for figure 2.9

	European Union	Canada	Mexico	Costa Rica	All other
2016	124.7	45.2	0.8	0.1	0.7
2017	135.5	44.0	2.0	0.0	1.9
2018	138.1	48.1	4.2	0.1	1.2
2019	128.6	53.0	4.5	0.8	1.0

Source: USITC/USDOC DataWeb, Schedule B 0714.20 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.9.

Table H.12 U.S. exports of almonds to major markets, 2016–19 (million dollars) for figure 2.10

	European Union	India	Canada	Japan	All other
2016	1,621	490	270	233	1,885
2017	1,568	658	256	226	1,773
2018	1,610	600	277	258	1,787
2019	1,806	733	284	276	1,803

Source: USITC/USDOC DataWeb, HTS lines 0802.11, 0802.12, and 2008.19.4000 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.10.

Table H.13 U.S. exports of pistachios to major markets, 2016–19 (million dollars) for figure 2.11

	European Union	Hong Kong	China	Canada	All other
2016	381	500	31	59	175
2017	462	622	42	79	314
2018	532	565	110	98	433
2019	649	450	327	103	482

Source: USITC/USDOC DataWeb, HTS lines 0802.51, 0802.52, and 2008.19.3020 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.11.

Table H.14 U.S. exports of hops and hop extract to major markets, 2016–19 (million dollars) for figure 2.12

	European Union	Canada	Brazil	Mexico	All other
2016	95	22	12	28	93
2017	112	25	21	24	103
2018	138	33	30	36	124
2019	165	41	36	25	117

Source: USITC/USDOC DataWeb, HTS lines 1210.10, 1210.20, and 1302.13 (accessed July 27, 2020).
Note on the EU data: Croatia entered the EU in 2013, and the United Kingdom (UK) departed the EU in 2019. For purposes of this figure, both Croatia and the UK are included in the EU data throughout the 2012–19 period. Correspond to figure 2.12.

Table H.15 Plot of gravity coefficient estimates for the non-MRL variables found in appendix F.1
nes = not elsewhere specified

Crop	Variable	Estimate	P-Value	Standard Error
Almonds, with shell	Both EU	5.916	0.000	0.781
Anise, badian, fennel, coriander	Both EU	0.313	0.108	0.195
Apples	Both EU	0.582	0.005	0.207
Apricots	Both EU	1.991	0.000	0.221
Artichokes	Both EU	3.219	0.000	0.790
Asparagus	Both EU	1.526	0.000	0.316
Avocados	Both EU	-0.921	0.007	0.342
Bananas	Both EU	2.479	0.000	0.491
Barley	Both EU	2.020	0.000	0.363
Beans, all	Both EU	0.042	0.870	0.257
Blueberries	Both EU	1.474	0.001	0.457
Buckwheat	Both EU	2.987	0.000	0.689
Cabbages and other brassicas	Both EU	2.211	0.000	0.260
Carrots and turnips	Both EU	2.063	0.000	0.266
Cauliflowers and broccoli	Both EU	4.636	0.000	0.394
Cherries	Both EU	1.922	0.000	0.275
Cherries, sour	Both EU	2.386	0.001	0.700
Chestnut	Both EU	0.775	0.028	0.352
Chick peas	Both EU	0.937	0.024	0.417
Chillies and peppers, dry	Both EU	0.062	0.836	0.298
Chillies and peppers, green	Both EU	0.505	0.069	0.278
Cloves	Both EU	4.330	0.000	0.555
Cocoa, beans	Both EU	3.612	0.000	0.715
Coconuts	Both EU	-3.458	0.218	2.806
Coffee, green	Both EU	-0.918	0.001	0.284
Cottonseed	Both EU	2.548	0.001	0.768
Cranberries	Both EU	-1.816	0.000	0.359
Cucumbers and gherkins	Both EU	3.305	0.000	0.265
Currants	Both EU	7.253	0.000	0.853
Dates	Both EU	0.357	0.270	0.323
Eggplants (aubergines)	Both EU	2.048	0.000	0.532

Crop	Variable	Estimate	P-Value	Standard Error
Fibre crops nes	Both EU	-0.629	0.129	0.415
Figs	Both EU	2.240	0.000	0.242
Fruit, fresh nes	Both EU	0.528	0.086	0.307
Fruit, tropical fresh nes	Both EU	4.072	0.000	0.982
Garlic	Both EU	1.354	0.000	0.381
Ginger	Both EU	-2.767	0.000	0.650
Gooseberries	Both EU	24.771		
Grapefruit (inc. pomelos)	Both EU	0.864	0.007	0.320
Grapes	Both EU	2.120	0.000	0.224
Hazelnuts, with shell	Both EU	3.255	0.000	0.921
Honey, natural	Both EU	1.147	0.000	0.193
Hops	Both EU	-3.239	0.000	0.397
Kiwi fruit	Both EU	0.399	0.061	0.213
Leeks, other alliaceous vegetables	Both EU	1.590	0.000	0.245
Lemons and limes	Both EU	0.313	0.225	0.258
Lentils	Both EU	2.337	0.000	0.327
Lettuce and chicory	Both EU	4.991	0.000	0.295
Linseed	Both EU	0.705	0.134	0.471
Maize	Both EU	0.708	0.004	0.243
Maize, green	Both EU	0.246	0.598	0.467
Mangoes, mangosteens, guavas	Both EU	-0.082	0.900	0.650
Melons, other (inc. cantaloupes)	Both EU	0.429	0.071	0.237
Millet	Both EU	-3.582	0.000	0.696
Mushrooms and truffles	Both EU	0.863	0.001	0.257
Mustard seed	Both EU	0.289	0.375	0.325
Nutmeg, mace and cardamoms	Both EU	1.359	0.000	0.283
Oats	Both EU	3.641	0.000	0.336
Oilseeds nes	Both EU	-0.092	0.781	0.331
Olives	Both EU	7.012	0.000	0.873
Onions, dry	Both EU	-0.767	0.005	0.271
Onions, shallots, green	Both EU	-1.294	0.002	0.410
Oranges	Both EU	1.729	0.000	0.225
Papayas	Both EU	-6.312	0.000	1.315
Peaches and nectarines	Both EU	1.457	0.000	0.244
Pears	Both EU	-0.052	0.830	0.241
Peas, all	Both EU	0.748	0.006	0.274
Pepper (*Piper* spp.)	Both EU	0.366	0.161	0.261
Peppermint	Both EU	5.847	0.000	1.484
Persimmons	Both EU	-1.013	0.088	0.595
Pineapples	Both EU	-3.929	0.000	0.688
Pistachios	Both EU	2.990	0.000	0.384

Crop	Variable	Estimate	P-Value	Standard Error
Plantains and others	Both EU	16.254	0.000	2.575
Plums and sloes	Both EU	0.913	0.000	0.261
Poppy seed	Both EU	1.640	0.000	0.333
Potatoes	Both EU	1.461	0.000	0.268
Pumpkins, squash and gourds	Both EU	2.565	0.000	0.302
Quinces	Both EU	2.410	0.000	0.351
Quinoa	Both EU	1.387	0.041	0.678
Rapeseed	Both EU	1.672	0.000	0.436
Rye	Both EU	0.648	0.058	0.342
Sesame seed	Both EU	0.539	0.158	0.382
Sorghum	Both EU	0.463	0.573	0.821
Soybeans	Both EU	0.570	0.260	0.506
Spinach	Both EU	2.855	0.000	0.286
Strawberries	Both EU	1.808	0.000	0.263
Sugar beet	Both EU	4.969	0.000	0.825
Sunflower seed	Both EU	0.658	0.005	0.236
Sweet potatoes	Both EU	-5.207	0.002	1.645
Tangerines, mandarins, clementines, satsumas	Both EU	1.258	0.000	0.252
Tea	Both EU	0.248	0.225	0.205
Tobacco, unmanufactured	Both EU	-0.482	0.011	0.189
Tomatoes	Both EU	2.845	0.000	0.242
Triticale	Both EU	4.109	0.000	0.430
Vanilla	Both EU	0.415	0.155	0.292
Vegetables, fresh nes	Both EU	0.449	0.121	0.290
Walnuts, with shell	Both EU	3.139	0.000	0.496
Watermelons	Both EU	4.249	0.000	0.593
Wheat	Both EU	1.368	0.000	0.258
Anise, badian, fennel, coriander	Colonial Tie	0.789	0.000	0.201
Apples	Colonial Tie	1.752	0.000	0.159
Apricots	Colonial Tie	1.675	0.000	0.416
Artichokes	Colonial Tie	1.884	0.000	0.461
Asparagus	Colonial Tie	-3.343	0.001	0.985
Avocados	Colonial Tie	1.085	0.007	0.404
Bananas	Colonial Tie	-0.736	0.025	0.329
Barley	Colonial Tie	0.346	0.359	0.377
Beans, all	Colonial Tie	1.936	0.000	0.244
Blueberries	Colonial Tie	-0.169	0.844	0.862
Buckwheat	Colonial Tie	0.307	0.629	0.636
Cabbages and other brassicas	Colonial Tie	1.235	0.006	0.445
Carrots and turnips	Colonial Tie	2.035	0.000	0.462
Cauliflowers and broccoli	Colonial Tie	0.473	0.437	0.609

Crop	Variable	Estimate	P-Value	Standard Error
Cherries	Colonial Tie	0.179	0.734	0.525
Cherries, sour	Colonial Tie	2.130	0.000	0.605
Chestnut	Colonial Tie	-4.765	0.000	0.739
Chick peas	Colonial Tie	0.813	0.010	0.316
Chillies and peppers, dry	Colonial Tie	0.291	0.275	0.266
Chillies and peppers, green	Colonial Tie	1.457	0.021	0.632
Cloves	Colonial Tie	-0.365	0.517	0.563
Cocoa, beans	Colonial Tie	1.889	0.003	0.628
Coconuts	Colonial Tie	0.828	0.164	0.594
Coffee, green	Colonial Tie	-0.657	0.000	0.179
Cranberries	Colonial Tie	1.213	0.000	0.304
Cucumbers and gherkins	Colonial Tie	0.816	0.197	0.633
Dates	Colonial Tie	-3.831	0.000	0.751
Eggplants (aubergines)	Colonial Tie	0.524	0.474	0.731
Fibre crops nes	Colonial Tie	0.459	0.503	0.687
Figs	Colonial Tie	0.113	0.837	0.549
Fruit, fresh nes	Colonial Tie	0.646	0.020	0.277
Fruit, tropical fresh nes	Colonial Tie	6.544	0.001	1.899
Garlic	Colonial Tie	-2.331	0.000	0.566
Ginger	Colonial Tie	1.058	0.000	0.269
Grapefruit (inc. pomelos)	Colonial Tie	0.513	0.037	0.247
Grapes	Colonial Tie	1.055	0.001	0.322
Honey, natural	Colonial Tie	0.585	0.091	0.346
Hops	Colonial Tie	0.730	0.005	0.260
Kiwi fruit	Colonial Tie	-3.224	0.000	0.628
Leeks, other alliaceous vegetables	Colonial Tie	-0.268	0.545	0.443
Lemons and limes	Colonial Tie	0.492	0.074	0.276
Lentils	Colonial Tie	-0.762	0.041	0.373
Lettuce and chicory	Colonial Tie	3.633	0.000	0.862
Linseed	Colonial Tie	-2.191	0.000	0.426
Maize	Colonial Tie	-0.457	0.328	0.468
Maize, green	Colonial Tie	-0.914	0.023	0.402
Mangoes, mangosteens, guavas	Colonial Tie	2.117	0.000	0.377
Melons, other (inc. cantaloupes)	Colonial Tie	0.789	0.011	0.310
Mushrooms and truffles	Colonial Tie	-2.646	0.000	0.458
Mustard seed	Colonial Tie	-0.564	0.133	0.375
Nutmeg, mace and cardamoms	Colonial Tie	1.408	0.000	0.331
Oats	Colonial Tie	1.243	0.008	0.469
Oilseeds nes	Colonial Tie	0.246	0.583	0.449
Onions, dry	Colonial Tie	0.548	0.038	0.264
Onions, shallots, green	Colonial Tie	0.789	0.006	0.288

Crop	Variable	Estimate	P-Value	Standard Error
Oranges	Colonial Tie	1.635	0.000	0.263
Papayas	Colonial Tie	1.737	0.002	0.554
Peaches and nectarines	Colonial Tie	2.030	0.000	0.341
Pears	Colonial Tie	1.324	0.001	0.415
Peas, all	Colonial Tie	-0.697	0.038	0.335
Pepper (*Piper* spp.)	Colonial Tie	-0.012	0.957	0.226
Persimmons	Colonial Tie	0.246	0.708	0.655
Pineapples	Colonial Tie	0.001	0.999	0.937
Pistachios	Colonial Tie	-3.428	0.000	0.836
Plantains and others	Colonial Tie	-2.997	0.002	0.981
Plums and sloes	Colonial Tie	0.215	0.515	0.330
Poppy seed	Colonial Tie	-0.347	0.566	0.604
Potatoes	Colonial Tie	2.321	0.000	0.571
Pumpkins, squash and gourds	Colonial Tie	2.073	0.000	0.380
Pyrethrum, dried	Colonial Tie	4.071	0.827	18.592
Quinces	Colonial Tie	-1.531	0.311	1.510
Quinoa	Colonial Tie	-0.058	0.936	0.722
Rapeseed	Colonial Tie	-3.405	0.000	0.873
Rye	Colonial Tie	0.346	0.747	1.073
Sesame seed	Colonial Tie	0.992	0.001	0.294
Soybeans	Colonial Tie	1.257	0.000	0.269
Spinach	Colonial Tie	-0.694	0.371	0.776
Strawberries	Colonial Tie	0.685	0.119	0.439
Sugar beet	Colonial Tie	3.472	0.034	1.640
Sunflower seed	Colonial Tie	-0.107	0.809	0.442
Sweet potatoes	Colonial Tie	-0.357	0.193	0.274
Tangerines, mandarins, clementines, satsumas	Colonial Tie	1.786	0.000	0.329
Tea	Colonial Tie	1.809	0.000	0.169
Tobacco, unmanufactured	Colonial Tie	0.306	0.076	0.173
Tomatoes	Colonial Tie	3.398	0.000	0.390
Vanilla	Colonial Tie	0.167	0.695	0.425
Vegetables, fresh nes	Colonial Tie	1.266	0.000	0.360
Walnuts, with shell	Colonial Tie	-3.257	0.000	0.824
Watermelons	Colonial Tie	1.904	0.020	0.818
Wheat	Colonial Tie	1.772	0.000	0.176
Almonds, with shell	Common Language	1.392	0.000	0.384
Anise, badian, fennel, coriander	Common Language	1.087	0.000	0.127
Apples	Common Language	0.302	0.010	0.118
Apricots	Common Language	0.544	0.000	0.093
Artichokes	Common Language	0.399	0.032	0.186
Asparagus	Common Language	0.469	0.009	0.181

Crop	Variable	Estimate	P-Value	Standard Error
Avocados	Common Language	-1.060	0.000	0.182
Bananas	Common Language	-0.635	0.001	0.194
Barley	Common Language	0.755	0.000	0.108
Beans, all	Common Language	-0.060	0.567	0.104
Blueberries	Common Language	0.179	0.389	0.208
Buckwheat	Common Language	0.147	0.512	0.225
Cabbages and other brassicas	Common Language	0.243	0.145	0.167
Carrots and turnips	Common Language	0.558	0.000	0.126
Cashew nuts, with shell	Common Language	9.446	0.000	1.376
Cassava	Common Language	21.097	0.000	2.691
Cauliflowers and broccoli	Common Language	0.046	0.649	0.101
Cherries	Common Language	1.131	0.000	0.179
Cherries, sour	Common Language	0.990	0.000	0.217
Chestnut	Common Language	0.224	0.205	0.177
Chick peas	Common Language	0.920	0.000	0.140
Chillies and peppers, dry	Common Language	-0.143	0.305	0.139
Chillies and peppers, green	Common Language	0.210	0.262	0.187
Cloves	Common Language	0.817	0.000	0.208
Cocoa, beans	Common Language	-0.407	0.061	0.217
Coconuts	Common Language	0.507	0.159	0.360
Coffee, green	Common Language	0.151	0.194	0.116
Cottonseed	Common Language	0.886	0.004	0.304
Cranberries	Common Language	-0.039	0.867	0.233
Cucumbers and gherkins	Common Language	0.393	0.056	0.206
Currants	Common Language	1.203	0.000	0.217
Dates	Common Language	0.215	0.461	0.291
Eggplants (aubergines)	Common Language	-0.084	0.726	0.239
Fibre crops nes	Common Language	-0.423	0.111	0.265
Figs	Common Language	0.942	0.000	0.224
Fruit, fresh nes	Common Language	0.872	0.000	0.178
Fruit, tropical fresh nes	Common Language	4.442	0.000	1.109
Garlic	Common Language	0.201	0.283	0.187
Ginger	Common Language	-0.683	0.001	0.200
Gooseberries	Common Language	1.851	0.015	0.764
Grapefruit (inc. pomelos)	Common Language	-0.331	0.073	0.185
Grapes	Common Language	0.103	0.530	0.165
Hazelnuts, with shell	Common Language	1.926	0.000	0.422
Honey, natural	Common Language	0.701	0.000	0.105
Hops	Common Language	0.515	0.000	0.136
Kiwi fruit	Common Language	0.831	0.000	0.131
Leeks, other alliaceous vegetables	Common Language	0.986	0.000	0.148

Crop	Variable	Estimate	P-Value	Standard Error
Lemons and limes	Common Language	0.592	0.000	0.154
Lentils	Common Language	0.632	0.000	0.177
Lettuce and chicory	Common Language	0.953	0.000	0.124
Linseed	Common Language	1.070	0.000	0.237
Maize	Common Language	0.039	0.732	0.113
Maize, green	Common Language	0.067	0.758	0.217
Mangoes, mangosteens, guavas	Common Language	-1.834	0.000	0.297
Melons, other (inc. cantaloupes)	Common Language	0.253	0.221	0.207
Millet	Common Language	0.752	0.009	0.289
Mushrooms and truffles	Common Language	0.149	0.258	0.132
Mustard seed	Common Language	0.490	0.003	0.164
Nutmeg, mace and cardamoms	Common Language	-0.103	0.597	0.195
Oats	Common Language	0.380	0.008	0.143
Oilseeds nes	Common Language	0.636	0.000	0.128
Olives	Common Language	1.369	0.000	0.306
Onions, dry	Common Language	0.549	0.000	0.125
Onions, shallots, green	Common Language	-0.074	0.801	0.294
Oranges	Common Language	-0.398	0.002	0.131
Papayas	Common Language	-2.196	0.000	0.549
Peaches and nectarines	Common Language	0.680	0.000	0.121
Pears	Common Language	0.501	0.001	0.152
Peas, all	Common Language	1.154	0.000	0.152
Pepper (*Piper* spp.)	Common Language	0.560	0.000	0.154
Peppermint	Common Language	-4.378	0.610	8.585
Persimmons	Common Language	0.923	0.000	0.249
Pineapples	Common Language	-0.487	0.018	0.207
Pistachios	Common Language	0.285	0.215	0.230
Plantains and others	Common Language	0.132	0.712	0.357
Plums and sloes	Common Language	0.675	0.000	0.147
Poppy seed	Common Language	0.500	0.013	0.202
Potatoes	Common Language	0.174	0.318	0.174
Pumpkins, squash and gourds	Common Language	-0.070	0.659	0.159
Pyrethrum, dried	Common Language	0.101	0.878	0.655
Quinces	Common Language	1.009	0.001	0.302
Quinoa	Common Language	0.305	0.148	0.211
Rapeseed	Common Language	-0.727	0.001	0.220
Rye	Common Language	0.053	0.730	0.154
Sesame seed	Common Language	0.029	0.851	0.156
Sorghum	Common Language	-0.024	0.919	0.234
Soybeans	Common Language	-1.215	0.000	0.211
Spinach	Common Language	1.232	0.000	0.243

Crop	Variable	Estimate	P-Value	Standard Error
Strawberries	Common Language	0.748	0.000	0.168
Sugar beet	Common Language	-0.478	0.050	0.244
Sunflower seed	Common Language	-0.067	0.552	0.113
Sweet potatoes	Common Language	0.352	0.456	0.471
Tangerines, mandarins, clementines, satsumas	Common Language	0.373	0.003	0.124
Tea	Common Language	0.928	0.000	0.110
Tobacco, unmanufactured	Common Language	0.251	0.003	0.086
Tomatoes	Common Language	0.074	0.573	0.132
Triticale	Common Language	-0.250	0.312	0.247
Vanilla	Common Language	1.056	0.000	0.164
Vegetables, fresh nes	Common Language	0.519	0.000	0.123
Walnuts, with shell	Common Language	1.260	0.001	0.393
Watermelons	Common Language	0.005	0.983	0.244
Wheat	Common Language	0.346	0.001	0.101
Almonds, with shell	Distance	0.691	0.000	0.186
Anise, badian, fennel, coriander	Distance	-0.616	0.000	0.075
Apples	Distance	-0.883	0.000	0.097
Apricots	Distance	-1.275	0.000	0.121
Artichokes	Distance	-1.817	0.002	0.588
Asparagus	Distance	-1.116	0.000	0.105
Avocados	Distance	-1.048	0.000	0.111
Bananas	Distance	-1.852	0.000	0.339
Barley	Distance	-1.854	0.000	0.117
Beans, all	Distance	-1.513	0.000	0.105
Blueberries	Distance	-2.186	0.000	0.231
Buckwheat	Distance	-0.367	0.005	0.130
Cabbages and other brassicas	Distance	-1.944	0.000	0.124
Carrots and turnips	Distance	-1.734	0.000	0.095
Cashew nuts, with shell	Distance	0.811	0.000	0.225
Cassava	Distance	-1.157	0.013	0.465
Cauliflowers and broccoli	Distance	-2.552	0.000	0.146
Cherries	Distance	-0.061	0.599	0.117
Cherries, sour	Distance	-0.786	0.001	0.227
Chestnut	Distance	-2.175	0.000	0.183
Chick peas	Distance	-1.964	0.000	0.182
Chillies and peppers, dry	Distance	-1.299	0.000	0.096
Chillies and peppers, green	Distance	-1.500	0.000	0.137
Cloves	Distance	0.112	0.252	0.098
Cocoa, beans	Distance	-1.612	0.000	0.191
Coconuts	Distance	-0.385	0.232	0.322
Coffee, green	Distance	-0.544	0.000	0.066

Crop	Variable	Estimate	P-Value	Standard Error
Cottonseed	Distance	-0.848	0.008	0.321
Cranberries	Distance	-1.243	0.000	0.200
Cucumbers and gherkins	Distance	-1.431	0.000	0.194
Currants	Distance	-0.626	0.001	0.183
Dates	Distance	-0.670	0.029	0.307
Eggplants (aubergines)	Distance	-1.703	0.000	0.460
Fibre crops nes	Distance	-0.649	0.000	0.183
Figs	Distance	-0.719	0.000	0.142
Fruit, fresh nes	Distance	-0.461	0.001	0.142
Fruit, tropical fresh nes	Distance	1.149	0.000	0.165
Garlic	Distance	-0.827	0.000	0.096
Ginger	Distance	-0.725	0.000	0.143
Gooseberries	Distance	-0.490	0.699	1.269
Grapefruit (inc. pomelos)	Distance	-0.044	0.667	0.103
Grapes	Distance	0.061	0.655	0.137
Hazelnuts, with shell	Distance	0.589	0.001	0.176
Honey, natural	Distance	-0.668	0.000	0.076
Hops	Distance	-0.704	0.000	0.103
Kiwi fruit	Distance	-0.461	0.000	0.116
Leeks, other alliaceous vegetables	Distance	-1.337	0.000	0.091
Lemons and limes	Distance	-1.280	0.000	0.169
Lentils	Distance	-0.872	0.000	0.170
Lettuce and chicory	Distance	-1.366	0.000	0.100
Linseed	Distance	-0.161	0.482	0.230
Maize	Distance	-1.570	0.000	0.120
Maize, green	Distance	-1.625	0.000	0.230
Mangoes, mangosteens, guavas	Distance	-1.279	0.000	0.192
Melons, other (inc. cantaloupes)	Distance	-1.130	0.000	0.163
Millet	Distance	-0.803	0.012	0.319
Mushrooms and truffles	Distance	-1.073	0.000	0.095
Mustard seed	Distance	-0.010	0.944	0.146
Nutmeg, mace and cardamoms	Distance	-0.398	0.000	0.101
Oats	Distance	-1.704	0.000	0.150
Oilseeds nes	Distance	-0.915	0.000	0.139
Olives	Distance	-4.134	0.000	0.777
Onions, dry	Distance	-1.444	0.000	0.086
Onions, shallots, green	Distance	-0.840	0.000	0.187
Oranges	Distance	-0.679	0.003	0.225
Papayas	Distance	-3.905	0.000	0.348
Peaches and nectarines	Distance	-1.303	0.000	0.134
Pears	Distance	-0.991	0.000	0.109

Crop	Variable	Estimate	P-Value	Standard Error
Peas, all	Distance	-1.703	0.000	0.125
Pepper (*Piper* spp.)	Distance	-0.231	0.002	0.076
Peppermint	Distance	0.557	0.643	1.203
Persimmons	Distance	-1.289	0.000	0.197
Pineapples	Distance	-2.333	0.000	0.187
Pistachios	Distance	0.338	0.011	0.132
Plantains and others	Distance	-1.449	0.000	0.413
Plums and sloes	Distance	-0.223	0.133	0.148
Poppy seed	Distance	-0.724	0.000	0.156
Potatoes	Distance	-0.843	0.000	0.124
Pumpkins, squash and gourds	Distance	-1.420	0.000	0.159
Pyrethrum, dried	Distance	-0.238	0.976	7.965
Quinces	Distance	-1.176	0.000	0.154
Quinoa	Distance	-0.931	0.005	0.333
Rapeseed	Distance	-0.170	0.463	0.231
Rye	Distance	-0.498	0.003	0.169
Sesame seed	Distance	-0.841	0.000	0.115
Sorghum	Distance	-2.913	0.000	0.452
Soybeans	Distance	-1.829	0.000	0.285
Spinach	Distance	-1.204	0.000	0.153
Strawberries	Distance	-1.302	0.000	0.094
Sugar beet	Distance	-1.667	0.000	0.351
Sunflower seed	Distance	-0.866	0.000	0.105
Sweet potatoes	Distance	-2.601	0.000	0.347
Tangerines, mandarins, clementines, satsumas	Distance	-1.411	0.000	0.107
Tea	Distance	-0.555	0.000	0.085
Tobacco, unmanufactured	Distance	-0.551	0.000	0.060
Tomatoes	Distance	-1.818	0.000	0.140
Triticale	Distance	-1.365	0.000	0.359
Vanilla	Distance	-0.706	0.000	0.136
Vegetables, fresh nes	Distance	-1.828	0.000	0.091
Walnuts, with shell	Distance	-0.126	0.776	0.443
Watermelons	Distance	-3.028	0.000	0.242
Wheat	Distance	-1.472	0.000	0.090
Almonds, with shell	International Border	-6.319	0.000	1.534
Anise, badian, fennel, coriander	International Border	-1.965	0.000	0.295
Apples	International Border	-4.174	0.000	0.289
Apricots	International Border	-4.734	0.000	0.374
Artichokes	International Border	-5.082	0.000	1.211
Asparagus	International Border	-4.524	0.000	0.410
Avocados	International Border	-4.556	0.000	0.494

Crop	Variable	Estimate	P-Value	Standard Error
Bananas	International Border	-3.231	0.000	0.525
Barley	International Border	-3.279	0.000	0.312
Beans, all	International Border	-3.533	0.000	0.262
Blueberries	International Border	0.957	0.138	0.644
Buckwheat	International Border	-4.413	0.000	0.595
Cabbages and other brassicas	International Border	-5.606	0.000	0.354
Carrots and turnips	International Border	-4.351	0.000	0.263
Cashew nuts, with shell	International Border	-13.040	0.000	1.056
Cauliflowers and broccoli	International Border	-4.534	0.000	0.454
Cherries	International Border	-7.059	0.000	0.407
Cherries, sour	International Border	-3.718	0.000	0.768
Chestnut	International Border	-1.359	0.000	0.349
Chick peas	International Border	-0.664	0.061	0.354
Chillies and peppers, dry	International Border	-0.591	0.212	0.474
Chillies and peppers, green	International Border	-4.028	0.000	0.417
Cloves	International Border	-0.444	0.315	0.442
Cocoa, beans	International Border	-0.741	0.171	0.541
Coconuts	International Border	-9.042	0.000	1.335
Coffee, green	International Border	-0.470	0.341	0.495
Cottonseed	International Border	-6.882	0.000	1.210
Cranberries	International Border	1.037	0.274	0.948
Cucumbers and gherkins	International Border	-6.936	0.000	0.519
Currants	International Border	-5.801	0.000	0.709
Dates	International Border	-3.506	0.001	1.069
Eggplants (aubergines)	International Border	-8.087	0.000	0.761
Fibre crops nes	International Border	-1.114	0.040	0.542
Figs	International Border	-2.652	0.000	0.382
Fruit, fresh nes	International Border	-3.717	0.000	0.376
Fruit, tropical fresh nes	International Border	-15.186	0.000	1.279
Garlic	International Border	-4.189	0.000	0.430
Ginger	International Border	-5.749	0.000	0.473
Gooseberries	International Border	-4.883	0.000	0.941
Grapefruit (inc. pomelos)	International Border	-3.012	0.000	0.440
Grapes	International Border	-9.033	0.000	0.402
Hazelnuts, with shell	International Border	-7.177	0.000	1.120
Honey, natural	International Border	-3.492	0.000	0.213
Hops	International Border	-1.884	0.000	0.429
Kiwi fruit	International Border	-1.098	0.010	0.428
Leeks, other alliaceous vegetables	International Border	-3.874	0.000	0.355
Lemons and limes	International Border	-1.664	0.000	0.451
Lentils	International Border	-2.815	0.000	0.451

Crop	Variable	Estimate	P-Value	Standard Error
Lettuce and chicory	International Border	-4.027	0.000	0.303
Linseed	International Border	-2.615	0.000	0.667
Maize	International Border	-5.934	0.000	0.256
Maize, green	International Border	-5.819	0.000	0.619
Mangoes, mangosteens, guavas	International Border	-5.953	0.000	0.617
Melons, other (inc. cantaloupes)	International Border	-4.976	0.000	0.529
Millet	International Border	-3.477	0.000	0.802
Mushrooms and truffles	International Border	-4.236	0.000	0.309
Mustard seed	International Border	-2.629	0.000	0.553
Nutmeg, mace and cardamoms	International Border	-1.292	0.011	0.507
Oats	International Border	-3.939	0.000	0.458
Oilseeds nes	International Border	-2.318	0.000	0.321
Olives	International Border	2.507	0.172	1.837
Onions, dry	International Border	-6.176	0.000	0.438
Onions, shallots, green	International Border	-6.001	0.000	0.790
Oranges	International Border	-4.360	0.000	0.433
Papayas	International Border	-5.535	0.000	0.932
Peaches and nectarines	International Border	-4.900	0.000	0.384
Pears	International Border	-3.282	0.000	0.365
Peas, all	International Border	-1.867	0.000	0.303
Pepper (*Piper* spp.)	International Border	-2.039	0.000	0.297
Peppermint	International Border	-4.136	0.699	10.694
Persimmons	International Border	-5.387	0.000	0.542
Pineapples	International Border	-4.389	0.000	0.492
Pistachios	International Border	-3.331	0.000	0.797
Plantains and others	International Border	8.096	0.000	1.119
Plums and sloes	International Border	-6.740	0.000	0.394
Poppy seed	International Border	-0.193	0.748	0.600
Potatoes	International Border	-7.264	0.000	0.564
Pumpkins, squash and gourds	International Border	-4.638	0.000	0.373
Pyrethrum, dried	International Border	42.982		
Quinces	International Border	-3.649	0.000	0.521
Quinoa	International Border	30.472	0.999	42050.897
Rapeseed	International Border	-7.942	0.000	0.785
Rye	International Border	-5.937	0.000	0.529
Sesame seed	International Border	-3.962	0.000	0.374
Sorghum	International Border	-3.903	0.000	0.898
Soybeans	International Border	-3.015	0.000	0.766
Spinach	International Border	-7.970	0.000	0.519
Strawberries	International Border	-5.087	0.000	0.472
Sugar beet	International Border	-10.134	0.000	0.961

Crop	Variable	Estimate	P-Value	Standard Error
Sunflower seed	International Border	-3.247	0.000	0.308
Sweet potatoes	International Border	-5.697	0.000	0.784
Tangerines, mandarins, clementines, satsumas	International Border	-2.766	0.000	0.320
Tea	International Border	1.009	0.019	0.432
Tobacco, unmanufactured	International Border	-1.705	0.000	0.183
Tomatoes	International Border	-6.264	0.000	0.371
Triticale	International Border	-8.442	0.000	0.918
Vanilla	International Border	0.522	0.294	0.497
Vegetables, fresh nes	International Border	-4.772	0.000	0.285
Walnuts, with shell	International Border	-5.587	0.000	1.162
Watermelons	International Border	-3.253	0.000	0.548
Wheat	International Border	-4.858	0.000	0.316
Almonds, with shell	Pref. Trade Agree.	-2.144	0.000	0.522
Anise, badian, fennel, coriander	Pref. Trade Agree.	0.653	0.000	0.118
Apples	Pref. Trade Agree.	0.871	0.000	0.114
Apricots	Pref. Trade Agree.	1.964	0.000	0.251
Artichokes	Pref. Trade Agree.	1.172	0.053	0.605
Asparagus	Pref. Trade Agree.	0.532	0.030	0.245
Avocados	Pref. Trade Agree.	2.529	0.000	0.280
Bananas	Pref. Trade Agree.	1.044	0.000	0.261
Barley	Pref. Trade Agree.	0.474	0.011	0.186
Beans, all	Pref. Trade Agree.	0.351	0.020	0.151
Blueberries	Pref. Trade Agree.	0.451	0.166	0.325
Buckwheat	Pref. Trade Agree.	1.991	0.000	0.376
Cabbages and other brassicas	Pref. Trade Agree.	1.771	0.000	0.212
Carrots and turnips	Pref. Trade Agree.	1.609	0.000	0.126
Cauliflowers and broccoli	Pref. Trade Agree.	3.021	0.000	0.384
Cherries	Pref. Trade Agree.	2.296	0.000	0.235
Cherries, sour	Pref. Trade Agree.	0.580	0.106	0.359
Chestnut	Pref. Trade Agree.	0.831	0.000	0.234
Chick peas	Pref. Trade Agree.	0.330	0.119	0.211
Chillies and peppers, dry	Pref. Trade Agree.	-0.209	0.307	0.204
Chillies and peppers, green	Pref. Trade Agree.	2.058	0.000	0.192
Cloves	Pref. Trade Agree.	-0.021	0.940	0.277
Cocoa, beans	Pref. Trade Agree.	-1.390	0.000	0.328
Coconuts	Pref. Trade Agree.	1.597	0.000	0.440
Coffee, green	Pref. Trade Agree.	0.007	0.955	0.126
Cottonseed	Pref. Trade Agree.	2.750	0.000	0.355
Cranberries	Pref. Trade Agree.	1.894	0.000	0.288
Cucumbers and gherkins	Pref. Trade Agree.	3.152	0.000	0.291
Currants	Pref. Trade Agree.	2.635	0.000	0.424

Crop	Variable	Estimate	P-Value	Standard Error
Dates	Pref. Trade Agree.	1.673	0.000	0.240
Eggplants (aubergines)	Pref. Trade Agree.	3.677	0.000	0.357
Fibre crops nes	Pref. Trade Agree.	0.513	0.016	0.213
Figs	Pref. Trade Agree.	-0.087	0.655	0.195
Fruit, fresh nes	Pref. Trade Agree.	1.388	0.000	0.203
Fruit, tropical fresh nes	Pref. Trade Agree.	5.763	0.000	0.889
Garlic	Pref. Trade Agree.	1.272	0.000	0.165
Ginger	Pref. Trade Agree.	1.489	0.000	0.195
Gooseberries	Pref. Trade Agree.	-1.984	0.117	1.264
Grapefruit (inc. pomelos)	Pref. Trade Agree.	1.129	0.000	0.170
Grapes	Pref. Trade Agree.	1.950	0.000	0.152
Hazelnuts, with shell	Pref. Trade Agree.	-0.617	0.453	0.822
Honey, natural	Pref. Trade Agree.	0.559	0.000	0.099
Hops	Pref. Trade Agree.	1.722	0.000	0.223
Kiwi fruit	Pref. Trade Agree.	-0.025	0.848	0.133
Leeks, other alliaceous vegetables	Pref. Trade Agree.	0.386	0.049	0.196
Lemons and limes	Pref. Trade Agree.	0.835	0.000	0.151
Lentils	Pref. Trade Agree.	1.871	0.000	0.280
Lettuce and chicory	Pref. Trade Agree.	2.627	0.000	0.174
Linseed	Pref. Trade Agree.	2.581	0.000	0.397
Maize	Pref. Trade Agree.	0.892	0.000	0.132
Maize, green	Pref. Trade Agree.	0.502	0.067	0.274
Mangoes, mangosteens, guavas	Pref. Trade Agree.	1.504	0.000	0.316
Melons, other (inc. cantaloupes)	Pref. Trade Agree.	1.166	0.000	0.157
Millet	Pref. Trade Agree.	3.649	0.000	0.383
Mushrooms and truffles	Pref. Trade Agree.	0.880	0.000	0.180
Mustard seed	Pref. Trade Agree.	1.838	0.000	0.282
Nutmeg, mace and cardamoms	Pref. Trade Agree.	0.749	0.000	0.167
Oats	Pref. Trade Agree.	-0.068	0.859	0.382
Oilseeds nes	Pref. Trade Agree.	0.333	0.008	0.126
Olives	Pref. Trade Agree.	-5.964	0.000	1.212
Onions, dry	Pref. Trade Agree.	1.260	0.000	0.146
Onions, shallots, green	Pref. Trade Agree.	0.428	0.019	0.182
Oranges	Pref. Trade Agree.	1.294	0.000	0.153
Papayas	Pref. Trade Agree.	0.887	0.094	0.529
Peaches and nectarines	Pref. Trade Agree.	2.649	0.000	0.258
Pears	Pref. Trade Agree.	1.261	0.000	0.155
Peas, all	Pref. Trade Agree.	0.316	0.059	0.167
Pepper (*Piper* spp.)	Pref. Trade Agree.	0.877	0.000	0.140
Persimmons	Pref. Trade Agree.	3.544	0.000	0.390
Pineapples	Pref. Trade Agree.	2.977	0.000	0.392

Crop	Variable	Estimate	P-Value	Standard Error
Pistachios	Pref. Trade Agree.	0.654	0.072	0.364
Plantains and others	Pref. Trade Agree.	-3.261	0.000	0.814
Plums and sloes	Pref. Trade Agree.	2.198	0.000	0.193
Poppy seed	Pref. Trade Agree.	-0.464	0.136	0.311
Potatoes	Pref. Trade Agree.	2.714	0.000	0.276
Pumpkins, squash and gourds	Pref. Trade Agree.	1.150	0.000	0.199
Pyrethrum, dried	Pref. Trade Agree.	0.089	0.996	18.588
Quinces	Pref. Trade Agree.	3.525	0.000	0.320
Quinoa	Pref. Trade Agree.	1.235	0.017	0.519
Rapeseed	Pref. Trade Agree.	2.467	0.000	0.529
Rye	Pref. Trade Agree.	1.105	0.003	0.373
Sesame seed	Pref. Trade Agree.	0.487	0.007	0.180
Sorghum	Pref. Trade Agree.	1.024	0.003	0.340
Soybeans	Pref. Trade Agree.	-0.773	0.000	0.182
Spinach	Pref. Trade Agree.	3.441	0.000	0.307
Strawberries	Pref. Trade Agree.	2.004	0.000	0.229
Sugar beet	Pref. Trade Agree.	0.470	0.201	0.368
Sunflower seed	Pref. Trade Agree.	0.771	0.000	0.148
Sweet potatoes	Pref. Trade Agree.	2.382	0.000	0.383
Tangerines, mandarins, clementines, satsumas	Pref. Trade Agree.	1.692	0.000	0.163
Tea	Pref. Trade Agree.	0.591	0.000	0.147
Tobacco, unmanufactured	Pref. Trade Agree.	0.525	0.000	0.101
Tomatoes	Pref. Trade Agree.	3.072	0.000	0.234
Triticale	Pref. Trade Agree.	1.732	0.002	0.547
Vanilla	Pref. Trade Agree.	0.140	0.537	0.227
Vegetables, fresh nes	Pref. Trade Agree.	1.273	0.000	0.152
Walnuts, with shell	Pref. Trade Agree.	-0.658	0.146	0.452
Watermelons	Pref. Trade Agree.	1.352	0.000	0.237
Wheat	Pref. Trade Agree.	1.060	0.000	0.153
Almonds, with shell	Shared Border	1.603	0.051	0.822
Anise, badian, fennel, coriander	Shared Border	-0.237	0.266	0.213
Apples	Shared Border	1.152	0.000	0.150
Apricots	Shared Border	1.019	0.000	0.119
Artichokes	Shared Border	1.801	0.000	0.339
Asparagus	Shared Border	1.371	0.000	0.183
Avocados	Shared Border	1.401	0.000	0.206
Bananas	Shared Border	2.049	0.000	0.281
Barley	Shared Border	0.362	0.016	0.149
Beans, all	Shared Border	0.843	0.000	0.140
Blueberries	Shared Border	-1.039	0.000	0.217
Buckwheat	Shared Border	0.296	0.326	0.302

Crop	Variable	Estimate	P-Value	Standard Error
Cabbages and other brassicas	Shared Border	0.857	0.000	0.176
Carrots and turnips	Shared Border	0.774	0.000	0.131
Cashew nuts, with shell	Shared Border	-2.589	0.002	0.849
Cauliflowers and broccoli	Shared Border	0.897	0.000	0.130
Cherries	Shared Border	1.741	0.000	0.217
Cherries, sour	Shared Border	0.349	0.194	0.269
Chestnut	Shared Border	0.550	0.015	0.226
Chick peas	Shared Border	-0.429	0.197	0.332
Chillies and peppers, dry	Shared Border	-0.163	0.470	0.226
Chillies and peppers, green	Shared Border	1.097	0.000	0.228
Cloves	Shared Border	1.626	0.000	0.284
Cocoa, beans	Shared Border	1.371	0.000	0.204
Coconuts	Shared Border	1.900	0.000	0.447
Coffee, green	Shared Border	1.143	0.000	0.161
Cottonseed	Shared Border	2.156	0.000	0.452
Cranberries	Shared Border	-0.725	0.030	0.335
Cucumbers and gherkins	Shared Border	0.609	0.004	0.211
Currants	Shared Border	0.517	0.020	0.223
Dates	Shared Border	1.143	0.041	0.560
Eggplants (aubergines)	Shared Border	0.761	0.039	0.368
Fibre crops nes	Shared Border	0.691	0.015	0.285
Figs	Shared Border	1.693	0.000	0.240
Fruit, fresh nes	Shared Border	1.722	0.000	0.191
Fruit, tropical fresh nes	Shared Border	5.406	0.000	0.496
Garlic	Shared Border	0.636	0.001	0.193
Ginger	Shared Border	0.833	0.029	0.382
Gooseberries	Shared Border	2.799	0.000	0.585
Grapefruit (inc. pomelos)	Shared Border	1.118	0.000	0.230
Grapes	Shared Border	1.524	0.000	0.250
Hazelnuts, with shell	Shared Border	3.021	0.000	0.691
Honey, natural	Shared Border	0.350	0.052	0.180
Hops	Shared Border	-0.162	0.455	0.216
Kiwi fruit	Shared Border	1.333	0.000	0.170
Leeks, other alliaceous vegetables	Shared Border	0.466	0.003	0.156
Lemons and limes	Shared Border	0.821	0.000	0.207
Lentils	Shared Border	-0.568	0.097	0.343
Lettuce and chicory	Shared Border	0.564	0.000	0.117
Linseed	Shared Border	-0.237	0.559	0.405
Maize	Shared Border	0.576	0.000	0.147
Maize, green	Shared Border	1.076	0.020	0.462
Mangoes, mangosteens, guavas	Shared Border	1.897	0.000	0.322

Crop	Variable	Estimate	P-Value	Standard Error
Melons, other (inc. cantaloupes)	Shared Border	1.494	0.000	0.260
Millet	Shared Border	-0.446	0.183	0.335
Mushrooms and truffles	Shared Border	1.467	0.000	0.112
Mustard seed	Shared Border	0.921	0.000	0.219
Nutmeg, mace and cardamoms	Shared Border	0.498	0.007	0.183
Oats	Shared Border	0.880	0.000	0.214
Oilseeds nes	Shared Border	0.836	0.000	0.161
Olives	Shared Border	2.182	0.000	0.452
Onions, dry	Shared Border	1.144	0.000	0.152
Onions, shallots, green	Shared Border	2.015	0.000	0.319
Oranges	Shared Border	1.047	0.000	0.246
Papayas	Shared Border	3.308	0.000	0.510
Peaches and nectarines	Shared Border	0.272	0.086	0.159
Pears	Shared Border	0.225	0.238	0.190
Peas, all	Shared Border	-0.292	0.143	0.200
Pepper (*Piper* spp.)	Shared Border	-0.009	0.969	0.239
Persimmons	Shared Border	3.066	0.000	0.380
Pineapples	Shared Border	1.836	0.000	0.191
Pistachios	Shared Border	0.972	0.026	0.437
Plantains and others	Shared Border	0.642	0.148	0.444
Plums and sloes	Shared Border	1.212	0.000	0.230
Poppy seed	Shared Border	0.720	0.000	0.181
Potatoes	Shared Border	1.364	0.000	0.184
Pumpkins, squash and gourds	Shared Border	1.693	0.000	0.172
Pyrethrum, dried	Shared Border	1.839	0.815	7.869
Quinces	Shared Border	-0.180	0.456	0.241
Quinoa	Shared Border	0.242	0.289	0.229
Rapeseed	Shared Border	2.252	0.000	0.274
Rye	Shared Border	1.716	0.000	0.194
Sesame seed	Shared Border	-0.180	0.387	0.208
Sorghum	Shared Border	-0.221	0.655	0.496
Soybeans	Shared Border	0.707	0.042	0.348
Spinach	Shared Border	0.728	0.001	0.215
Strawberries	Shared Border	0.596	0.000	0.134
Sugar beet	Shared Border	3.309	0.000	0.503
Sunflower seed	Shared Border	0.382	0.016	0.158
Sweet potatoes	Shared Border	-1.078	0.178	0.801
Tangerines, mandarins, clementines, satsumas	Shared Border	0.488	0.001	0.141
Tea	Shared Border	0.365	0.028	0.166
Tobacco, unmanufactured	Shared Border	-0.044	0.785	0.163
Tomatoes	Shared Border	0.883	0.000	0.143

Crop	Variable	Estimate	P-Value	Standard Error
Triticale	Shared Border	2.546	0.000	0.335
Vanilla	Shared Border	0.525	0.005	0.189
Vegetables, fresh nes	Shared Border	0.762	0.000	0.121
Walnuts, with shell	Shared Border	2.923	0.000	0.337
Watermelons	Shared Border	1.419	0.000	0.277
Wheat	Shared Border	0.710	0.000	0.142

Source: USITC estimates.
Note: Correspond to figure 3.2.