UNDERSTANDING THE COMPAS MODEL: ASSUMPTIONS, STRUCTURE, AND ELASTICITY OF SUBSTITUTION

By

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This document is dedicated to my parents, S.O. Chung and Yoon Ja Koh.

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International trade and globalization have significant impacts on U.S. agriculture. With the growing productivity of agriculture, U.S. producers rely heavily on export markets. Enjoying a variety of food and a year-round supply of fresh fruit and vegetables, consumers benefit from increased imports. Recently, since the implementation of NAFTA (which was effective on January 1, 1994), U.S. agricultural trade with Mexico and Canada has expanded. Accordingly, each country has been involved in agricultural trade disputes concerning unfair trading practices.

The main object of this research is to critique and evaluate the COMPAS model that the U.S. International Trade Commission (ITC) uses to analyze the impact of unfair trade to a specific domestic industry. Understanding the underlying assumptions and structure of the COMPAS model is necessary. The underlying structure of COMPAS is an Armington type imperfect substitute trade model. The Armington model has been

applied widely for the analysis of trade policy changes; however its assumptions are strong restrictions for practical application.

The parametric Armington restrictions imposed on the double-log functional form were tested and comprehensively rejected for fresh tomato data implying that the COMPAS analysis based on the Armington assumptions may not explain correctly the effects of dumping at least for the domestic industry of fresh tomatoes in the United States. Estimation of elasticity of substitution was attempted by imposing the full Armington restrictions into the double-log demand model. The estimate is 1.1076, which is in the U.S. ITC's range of degree of substitution between U.S. fresh tomatoes and imports from Mexico (i.e., $1 \leq \sigma \leq 3$). This empirical estimate suggests that the U.S. ITC's range of degree of substitution for the U.S. fresh tomato industry was set inappropriately in that the range is too broad to categorize together. This research concludes that COMPAS should be carefully applied since the selection of value of elasticity of substitution affects the results of the COMPAS analysis.

CHAPTER 1
INTRODUCTION

International trade is the main element of globalization that has accelerated over the past two decades. The increasing liberalization of trade has resulted in the rising interdependence of countries. A number of international institutions have played an important role in promoting free trade including the World Bank, International Monetary Fund (IMF), and General Agreement on Tariffs and Trade (GATT), succeeded in 1995 by the World Trade Organization (WTO) (Soubbotina and Sheram, 2000). Furthermore, there has been an increase in Regional Trade Agreements (RTAs) such as the Asia Pacific Economic Cooperation (APEC), European Union (EU), and North American Free Trade Agreement (NAFTA).

Globalization has a significant influence on agriculture. World agriculture has become increasingly integrated. The recent development of trade agreements emphasizes freer access to world markets and expanding trade of agricultural commodities and processed food products. The 1994 WTO Agreement on Agriculture negotiated in the Uruguay Round addressed specific commitments to improve market access and reduce trade-distorting subsidies in agriculture. It is historically important because, for the first time, the agricultural sector was brought under the GATT/WTO multilateral trading system.

International trade is essential to agriculture in the United States. With the growing productivity of agriculture, U.S. producers rely heavily on export markets. U.S. consumers benefit from imports, enjoying a variety of food and a stabilized supply of

fresh fruit and vegetables throughout the year. About 20% of U.S. agricultural production is exported, and imports account for a growing share of U.S. consumption of agricultural products. Since the implementation of NAFTA, which was effective on January 1, 1994, U.S. agricultural trade has expanded, particularly with both Canada and Mexico growing faster than other regions. Between 1993 and 2000, U.S. agricultural exports to Canada and Mexico increased by 59%, while corresponding exports to the rest of the world grew only 10%. Likewise, U.S. agricultural imports from Canada and Mexico increased 86% for the same periods, compared with 42% for U.S. agricultural imports from the rest of the world (Zahniser and Link, 2002).

NAFTA is a regional trade agreement among Mexico, Canada, and the United States. NAFTA contains a detailed schedule for eliminating barriers to trade and investment over the 14 year-period that ends on January 1, 2008. Numerous tariffs and other restrictions were eliminated immediately on NAFTA's implementation. The remaining barriers are to be phased out during periods of 4, 9, or 14 years, depending on the commodity and the importing country. In addition, NAFTA provides a set of legal mechanisms for resolving trade disputes among the NAFTA partners.

Agricultural producers in each NAFTA country have been involved in disputes concerning countervailing duty measures and charges of dumping. Antidumping actions are brought by their government of domestic producers against foreign firms and the provisions are generally used to prevent international price discrimination (Meilke, 1997). Antidumping duties are imposed if imports are being sold for less than their normal (or fair) value and if those imports are causing or threaten to cause material injury to a domestic industry. On the other hand, a countervailing duty case is against action by

foreign governments. Countervailing duties are imposed on imports that are causing or threaten to cause material injury to a domestic industry; to offset subsidies provided by the government to exporters. Chapter 19 of NAFTA provides for the review of antidumping and countervailing duty determination.

Aspects of antidumping and countervailing duty have been incorporated into U.S. law at Subtitle VII of the Tariff Act of 1930, as amended. The U.S. antidumping and countervailing duty laws attempt to remedy unfair trading practices by imposing an additional duty on the dumped or subsidized imports with the purpose of ensuring fair trade. To impose extra duties for dumping, the U.S. Department of Commerce (DOC) must first find that the goods are being sold in the United States at prices below normal (or fair) value and report the margin of dumping. Second, the U.S. International Trade Commission (ITC) must analyze the effects of dumping and determine whether the imports in question are causing or threatening material injury to domestic producers of the domestic like product.

The U.S. ITC demonstrates the impact of unfair trade using an economic model named Commercial Policy Analysis System (COMPAS, Francois and Hall, 1993). COMPAS is a package of spreadsheets used to analyze trade-related gain or injury in specific domestic industries and the overall economy, as an industry-specific trade policy change. COMPAS is not used in a conclusive way but as guidance for the U.S. ITC to make their final decision (VanSickle, 2003).

The underlying model structure of COMPAS is an imperfect substitutes model also known as an Armington model. Armington (1969) presented a theory of demand for products that are distinguished by their kind and also by their country of origin. The

Armington model is relatively standard and has been applied widely for the analysis of trade policy changes in both partial and general equilibrium analyses.

The reliability of simulation results generated by COMPAS highly depends on the selection of parameter values used in the model such as price elasticity. Price elasticity establishes the responsiveness of trade flows to price changes. In particular, the cross-price elasticity between imports and domestic products (i.e., the elasticity of substitution) measures the degree to which lower prices would provide imports greater market share in the importing country. The elasticity of substitution plays an important role in the COMPAS analysis. Changes in trade policy affect the economy; and the size of those impacts largely depends on the magnitude of the elasticity (McDaniel and Balistreri, 2002).

Problem Statement

Even though elasticities are known to be key behavioral parameters for trade policy analysis, few studies estimate the elasticities empirically. Most partial or general equilibrium analyses, including COMPAS, do not undertake direct estimation of the elasticities but use rough estimates from the literature or calibrate those estimates for their own interests (Kapuscinski and Warr, 1996). Hence, an analysis of demand is necessary since it provides essential parameters for trade policy analysis.

Specifically, the elasticity of substitution in the COMPAS analysis is assumed to be imperfect according to Armington demand assumptions of a single constant elasticity of substitution and homotheticity of preference. However, the Armington assumptions depend on data that are unique and on the research problem of an individual researcher. If those assumptions were rejected by the data, the estimate of the elasticity of substitution would not correctly explain the situation in hand. Consequently, the credibility of the

COMPAS analysis comes into question for determining the impacts of trade policy changes.

Objectives

The main objectives of this research are to critique the COMPAS analysis and to provide insight for modeling international agricultural trade. Antidumping duty cases in the U.S. fresh tomato industry are studied to evaluate procedures for judging trade disputes.

Specific objectives are the following:

1. Understand the legal mechanisms of U.S. import relief laws.
2. Describe the condition of the fresh tomato industry in the United States and the recent history of trade disputes.
3. Analyze the structure of the U.S. ITC's economic model, COMPAS
4. Perform an empirical demand analysis on fresh tomatoes using econometric models in order to get input parameters or elasticities required for the COMPAS analysis.
5. Simulate COMPAS for the U.S. fresh tomato industry and compare with the U.S. ITC's analysis.
6. Evaluate the sensitivity of the COMPAS analysis and address the issue of credibility with the COMPAS analysis.

Data and Procedure

This research empirically estimates input parameters that are used to simulate trade impacts in the COMPAS model rather than attain them from studies already completed. To get the COMPAS input parameters (i.e., elasticities), an empirical demand analysis is conducted on fresh tomatoes in the United States. There are numerous approaches to analyze the demand for consumption goods. In this study, both parametric and nonparametric demand approaches are attempted. Parametric functional forms that include the Armington trade allocation model, Rotterdam model, and Almost Ideal

Demand System (AIDS) are estimated with conventional econometric software, while the nonparametric method for demand is analyzed to test for the compatibility of data with the theory of maximization of a utility function.

Parameter estimates from empirical demand models play an important role as inputs for the COMPAS model analysis. COMPAS runs in Microsoft Excel software. Once inputs are provided, output results are generated in the same worksheet. Furthermore, the sensitivity of the COMPAS analysis with respect to changes in an input parameter, particularly elasticity of substitution, is measured.

Monthly data for fresh tomatoes from 1990 to 2001 were used in this research. Price and quantity data for tomatoes were obtained from U.S. Tomato Statistics electronically published by Economic Research Service of the USDA (ERS, 2003b). Monthly import data during the same periods were collected from the World Trade Atlas program developed by Global Trade Information Services Inc. in cooperation with the Bureau of the Census of the U.S. Department of Commerce.

Organization

Chapter 2 overviews the legal mechanism of the U.S. import relief laws and describes the roles of U.S. agencies in the administration of those laws in the United States. The situation of the fresh tomato industry in the United States and the recent history of trade disputes are described in Chapter 3. In Chapter 4, the structure of the COMPAS model is analyzed in detail. Chapter 5 presents the theory of demand and conceptual demand analyses. In addition, literature on import demand modeling is reviewed. Chapter 6 presents empirical results from parametric and nonparametric demand analyses for fresh tomatoes and includes COMPAS simulation results using the

parameter estimates obtained from the empirical demand analysis. Finally, Chapter 7 summarizes and presents the significant conclusions of this research.

CHAPTER 2
LEGAL MECHANISMS OF UNFAIR TRADE ORDER

This chapter describes the definition and purpose of unfair trade such as dumping and subsidies. The legal mechanisms of U.S. unfair trade dispute resolution and the role and procedure of U.S. government agencies in administration of U.S. import relief laws are also explained.

Unfair Trade: Dumping and Subsidies

Dumping is described as price discrimination in which a producer charges a higher price in its home market than in an export market, according to Article VI of General Agreement on Tariffs and Trade (GATT) and the Agreement on Implementation of Article VI of the GATT 1994 ("Antidumping Agreement"). The Agreement on Subsidies of the GATT 1994 defines a subsidy as financial contributions provided by a government.

Dumping

Dumping occurs when an exporter sells its product in a foreign market for less than normal (or fair) value. Normal value is based on domestic price (i.e., the price the exporter charges in its home market). Third-country price for which the product is sold in a surrogate third country may be used in the absence of sufficient home market sales. In the absence of sufficient home market and third-country sales, constructed value also can be used as normal value.[1] The difference between the foreign (or export) and normal

[1] Constructed value is calculated as the sum of (1) the cost of materials, labor, and variable and fixed overhead; (2) packing expenses for shipment to the United States; (3) selling, general, and administrative expenses; and (4) profit (Powell and Barnett, 1997).

value is referred to as the "dumping margin." A formula for calculating the dumping margin is

$$\text{Dumping Margin} = \text{Normal Value - Export Price}^{2} \qquad (2\text{-}1)$$

If the dumping margin is positive, dumping occurs; if it is zero or negative, then no dumping occurs (Bhala, 2001). Dumping margins are also expressed in percentage, as a percentage of the export price:

$$\text{Dumping Margin} = \frac{\text{Normal Value - Export Price}}{\text{Export Price}} * 100 \qquad (2\text{-}2)$$

Dumping is price discrimination in international trade environments, where it is regarded as "unfair" practice. Dumping can occur in the following three cases. First, the industry must be imperfectly competitive, so that firms set prices rather than take market prices as given. Second, markets must be segmented, so that domestic residents cannot easily purchase goods intended for export. Third, the exporter faces a relatively more elastic demand curve for the product in the importing country and a relatively less elastic demand curve in home market. Given these conditions, a monopolistic firm may find that dumping is profitable (Krugman and Obstfeld, 2003).

Subsidies

Defined as "financial contribution" by a government, subsidies can take the form of a direct transfer of funds (e.g., loan or grant from the government to an industry), foregone government revenue (e.g., a tax credit), government provisions for purchasing goods or services, or income or price supports (Bhala and Kennedy, 1998). Not all

[2] Export price or constructed export price: The price is adjusted to (1) include U.S. packing and any countervailing duties imposed to offset export subsidies; and (2) exclude any U.S. import duties, any movement expenses incurred in bringing the product into the United States, any commissions, selling expenses incurred on behalf of the buyer, and further manufacturing expenses.

subsidies are countervailable.[3] Government expenditures for national defense, education, public health, and general infrastructure are not considered countervailable (i.e., general subsidies). Only benefits provided by governments to a specific industry or enterprise are countervailable subsidies (i.e., specific subsidies). Specific subsidies often enable their recipients to gain an unfair advantage over other domestic producers or over foreign producers. On the other hand, general subsidies normally do not grant such an advantage, and may be necessary because of the inability of the price system to distribute certain essential goods and services to all members of the society.

Under the GATT 1994 Agreements on Subsidies, subsidies are classified as either red, yellow, or green. Red subsidies are prohibited and countervailable. Yellow subsidies are permissible but countervailable. These subsidies are not prohibited but may be countervailed to offset injury, if they are specific. Most subsidies are yellow and subject to dispute since the definition of specificity is a controversial issue (Powell and Barnett, 1997). Green subsidies are non-countervailable. There are three categories of green subsidies: industrial research, subsidies for disadvantaged regions, and the adaptation of existing facilities to new environmental regulations.

In the Agreement on Agriculture, WTO members distinguish between subsidies that do not distort trade and those that do. The domestic support measures and export subsidies, identified in Annex 2 to the Agreement on Agriculture, that are eligible for exemption from countervailing duty laws must meet a list of qualifying requirements. Annex 2 covers general services including product-specific research, marketing and

[3] However, virtually all kinds of government assistance, including outright grants, loan guarantees, government equity investment, worker training assistance, and preferential freight rates are potentially countervailable if provided on terms that are more favorable than those available in the market.

promotion services. Direct payments are exempt, such as amounts for income support, crop insurance, and disaster assistance.

Import Relief Laws

This section discusses the various import relief laws: Section 201, antidumping, and countervailing duty laws. Each subchapter describes the role and procedure of U.S. government agencies in resolving trade disputes. In particular, antidumping and countervailing duty laws are administered jointly by the U.S. International Trade Commission (ITC) and U.S. Department of Commerce (DOC). Each agency has specific responsibilities under the law. The recent legislation concerning antidumping and countervailing duties – Byrd Amendment – is also briefly discussed.

Section 201 – Global Safeguard Investigations

Sections 201-204 of the U.S. Trade Act of 1974, known as the escape clause,[4] authorize the President of the United States to take action when a particular product is being imported into the United States in such increased quantities as to cause injury or threaten serious injury to a domestic industry producing a product like or directly competitive with the imported product.

Under these Sections, the U.S. ITC assesses whether U.S. industries are being seriously injured by imports. The U.S. ITC initiates investigations in response to petitions filed by representatives of affected industries, or as requested by the President or the U.S. Trade Representative. The investigation is also initiated upon receiving a resolution from

[4] GATT Article XIX, as further defined in the WTO Agreement on Safeguards, is referred to as the escape clause because it permits a country to "escape" temporarily from its obligations under GATT with respect to a particular product when increased imports of that product are causing or are threatening to cause serious injury to domestic products. Section 201 provides the legal framework under the U.S. law for the President to invoke U.S. rights under Article XIX (USITC, 2003).

the House Committee on Ways and Means or the Senate Committee on Finance, or by its own decision.

The U.S. ITC has 180 days from the day on which the petition, request, resolution, or institution on its own decision was received to conduct the investigation and report its findings and any recommendations to the President. The investigation has a two-phased process: (1) To determine if harm has been sustained by the domestic industry, and (2) to enact a remedy if harm was sustained. Public hearing must be held by the U.S. ITC in conjunction with the injury and remedy phases of its investigation. If the U.S. ITC makes a negative determination, the case is over. If the determination is affirmative, the U.S. ITC recommends to the President the type and amount of import relief in the form of increased tariffs, quotas, or tariff-rate quotas that are necessary to remedy the injury. Specifically for agricultural products, to render an affirmative provisional relief determination, Section 202 of the Trade Act of 1974 requires that the U.S. ITC (1995) find that

> On the basis of available information, whether increased imports of the perishable agricultural product are a substantial cause of serious injury or threat thereof to the domestic industry producing a like or directly competitive perishable product, and whether either (1) the serious injury is likely to be difficult to repair by reason of perishability of the like or directly competitive agricultural product; or (2) the serious injury cannot be timely prevented by final relief.

The first statutory criterion of increased imports is satisfied if the increase is either actual or relative to domestic production; and furthermore, it is satisfied even if the volume of imports is declining but imports are increasing relative to domestic production. The second criterion is serious injury or threat thereof. Serious injury is defined as a significant overall impairment in the position of a domestic industry; and threat of serious

injury is defined as serious injury that is clearly imminent. Section 202(c)(1) provides all economic factors which it considers relevant, including (but not limited to) the following:

(A) With respect to serious injury,
- (i) the significant idling of productive facilities in the domestic industry,
- (ii) the inability of a significant number of firms to carry out domestic production operations at a reasonable level of profit, and
- (iii) significant unemployment or underemployment within the domestic injury;

(B) With respect to threat of serious injury,
- (i) a decline in sales or market share, a higher and growing inventory, and a downward trend in production, profits, wages, productivity, or employment in the domestic industry,
- (ii) the extent to which firms in the domestic industry are unable to generate adequate capital to finance the modernization of their domestic plants and equipment, or are unable to maintain existing levels of expenditures for research and development, and
- (iii) the extent to which the U.S. market is the focal point for the diversion of exports of the article concerned by reason of restraints on exports of such article to, or on imports of such article into, third country markets.

The third statutory criterion requires consideration of whether the increased imports are a substantial cause of serious injury or threat thereof. The substantial cause is defined as a cause that is important and not less than any other causes. That is, the increased imports must be both an important cause of the serious injury or threat and a cause that is equal to or greater than any other causes. The U.S. ITC should consider the condition of the domestic industry over the course of the relevant business cycle, but may not aggregate the causes of declining demand associated with a recession or economic downturn in the U.S. economy into a single cause of serious injury or threat thereof.

To define the domestic industry, it is necessary to identify the article or articles like or directly competitive with the imported article. “Like” articles are those that are substantially identical inherent characteristics (i.e., materials from which made, appearance, quality, texture, etc.). “Directly competitive” articles, although not

substantially identical in their intrinsic characteristics, are substantially equivalent for commercial purposes (that is, they are adapted to the same uses and are essentially interchangeable therefore). In brief, while "like" means substantially identical in characteristics, "directly competitive" implies interchangeable. Section 202(c)(6)(A)(i) defines the term domestic industry to mean

> With respect to an article, the domestic producers as a whole of the like or directly competitive article or those producers whose collective production of the like or directly competitive article constitutes a major proportion of the total domestic production of such article.

The President has 60 days to decide what to do after receiving the U.S. ITC report that determines that the domestic industry has been found to be harmed; and a recommended course of action is outlined by the U.S. ITC. The President is free to accept the U.S. ITC's advice, to grant some other form of import relief, or to impose no relief (Macrory, 1997). The President must report to Congress the course of action he is taking. If his actions are different from that which was recommended by the U.S. ITC, he must explain the reason to Congress. Congress can direct the President to follow the course of action recommended by the U.S. ITC through a joint resolution within 90 days. There are special provisions that allow for provisional relief to be provided on an expedited basis pending completion of the investigation (ITDS, 2002).

Neither the U.S. ITC's determination (affirmative or negative) nor the President's decision can be appealed to the courts, although procedural defects can be challenged. Under Section 312 of the NAFTA Implementation Act, import relief may not be imposed against imports from a NAFTA country unless the U.S. ITC finds the imports from that

country account for a substantial share of total imports and contribute importantly to the serious injury.[5]

Domestic industries can expect assistance in alleviating injury for an initial period of up to 4 years. The period can be extended, but the total time cannot exceed 8 years. When relief is provided, the U.S. ITC monitors industry developments. The U.S. ITC advises the President of the probable economic effect on the industry of the reduction, modification, or termination of the relief in effect. When the measure exceeds three years, the U.S. ITC must submit a report to the President and Congress on the situation of the industry not later than the mid-point of the relief period. An industry receiving assistance can request an extension of assistance by submitting a petition six to nine months before the end of the relief period. At the conclusion of any relief period, the U.S. ITC is required to report to the President and Congress on the effectiveness of the relief action in facilitating the positive adjustment of the domestic industry to import competition.

Section 201 does not require a finding of an unfair trade practice, as do the antidumping and countervailing duty laws. However, the injury requirement under Section 201 is considered to be more difficult than those of the unfair trade statutes. Section 201 requires that the injury or threatened injury be "serious" and that the increased imports must be a "substantial cause" – important and not less than any other cause – of the serious injury or threat of serious injury (USITC, 2003). The injury standard in antidumping and countervailing duty cases requires "harm which is not

[5] However, under Articles 2.1 and 4.2 of the Agreement on Safeguards, for applying a safeguard measure, a WTO member should conduct an investigation considering imports from all sources and may not exclude imports from free-trade area. In the recent WTO Appellate Body report on definitive safeguard measures on imports of certain steel, the Appellate Body argued that the United States failed to comply with the requirement of "parallelism"(Sullivan, 2003).

inconsequential, immaterial, or unimportant." Section 201 provides relief from fair foreign competition so that a U.S. producer can improve its competitive position relative to foreign companies.

Antidumping Law[6]

The antidumping law, Sections 731-739 of the Tariff Act of 1930,[7] as amended, is designed to counteract the effect of unfair import pricing by imposing additional duties on imports that are found to be sold at less than normal (or fair) value, and to cause or threaten to cause material injury to a U.S. industry. The U.S. DOC decides whether imports are being sold at less than fair value (LTFV); and the U.S. ITC makes the injury determination.

The antidumping law was originally aimed at international price discrimination and defined dumping as making sales to the United States at less than normal value. Since 1974, the law also has incorporated a sales-below-cost provision under which sales to the United States at prices below fully allocated cost of production will in effect be found to be dumped, even if they are not priced below normal value.

An antidumping investigation is commenced by the filing of a petition requesting relief on behalf of the domestic industry producing the domestic like product. A petition is considered to have been filed on behalf of a domestic industry if (1) the domestic producers who support the petition account for at least 25% of the total production of the

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[6] Most of descriptions with regard to the antidumping law refer to Powell and Barnett (1997), unless otherwise indicated.

[7] Article VI of GATT 1947, and the Agreement on Implementation of Article VI of GATT 1994 ("Antidumping Agreement") that authorize World Trade Organization (WTO) members to impose antidumping duties when products are dumped and cause material injury to a domestic industry, have been incorporated into U.S. law at Subtitle B of Title VII (Section 731-739) of the Tariff Act of 1930, as amended.

domestic like product, and (2) the domestic producers who support the petition account for more than 50% of the production of the domestic like product produced by that portion of the industry expressing support for or opposition to the petition. If the petition does not establish support of domestic producers accounting for more than 50% of the total production of the domestic like product, the U.S. DOC must poll the industry to determine if the required level of support for the petition exists (USITC, 2002a). The petition must contain information about the condition of the domestic industry, quantity and value of the imported products, prices in the United States for the imported products or comparable products, the number of employment, and the cost of producing the products.

The U.S. ITC issues a preliminary report after a 45-day investigation in which the U.S. ITC obtains and analyzes information to determine whether there is a reasonable indication that the domestic industry is materially injured or threatened with material injury or that the establishment of a domestic industry has been materially retarded by reason of dumped imports.[8] The first step in the U.S. ITC's analysis is to determine what the relevant domestic industry is. Section 771(4)(A) of the Tariff Act of 1930 defines the relevant domestic industry as the producers as a whole of a domestic like product, or those producers whose collective output of a domestic like product constitutes a major proportion of the total domestic production of the product. In turn, the Act defines domestic like product as a product that is like or most similar in characteristics and uses

[8] Determination of threat of material injury by reason of subject imports: The factors considered by the U.S. ITC in making a determination include the likelihood of increases in imports because of increases in production capacity or market penetration; the likelihood of increases in demand for imports because of imports prices depressing domestic prices; inventories of the subject import; and other demonstrable adverse trends.

with the subject imports involved in the investigation (USITC, 1996b). In analyzing domestic like product issues, the U.S. ITC generally considers a number of factors including (1) physical characteristics and uses; (2) interchangeability; (3) channels of distribution; (4) customer and producer perceptions of the products; (5) common manufacturing facilities; and, where appropriate, (6) price. Although the U.S. ITC should accept the U.S. DOC's determination as to the scope of the imports that are subject to investigation, the U.S. ITC determines which domestic products are like the imported products the U.S. DOC has identified. In defining the domestic like product, the U.S. ITC considers a number of factors such as physical characteristics and uses, interchangeability, channels of distribution, common manufacturing facilities, production processes, production employees, customer and producer perceptions, and sometimes price.

In assessing whether there is a reasonable indication that the domestic industry is materially injured or threatened with material injury by reason of allegedly LTFV imports, the U.S. ITC considers all relevant economic factors that illustrate the condition of the industry in the United States. These factors include output, sales, market shares, profits, productivity, return on investments, and utilization of capacity; inventories, employment, wages, growth, and ability to raise capital based on questionnaires issued to the domestic industry. No single factor is dispositive, and all relevant factors are considered within the context of the business cycle and conditions of competition that are distinctive to the affected industry.

In making a determination whether there is a reasonable indication that an industry in the United States is materially injured by reason of the imports under investigation, the U.S. ITC considers (1) the volume of imports of the subject products, (2) the effect of

imports of the products on prices for domestic like products, and (3) the impact of the subject imports on domestic producers of domestic like products. Typically, the U.S. ITC collects data for a 3-year period of investigation. Downward trends may be indicative of injury. If the domestic industry appears to be materially injured, the U.S. ITC further determines whether that injury is by reason of the allegedly dumped imports. To make this determination, the U.S. ITC issues questionnaires to importers and foreign producers, seeking information about the volume and value of the subject imports.

The U.S. ITC analyzes the price and volume effects of the imports and their impact on the domestic producers to determine whether the link between the dumped imports and the industry's performance is sufficient to warrant an affirmative outcome (Salonen, 1997). In evaluating the volume of imports, the U.S. ITC considers whether the volume of the subject imports, or any increase in that volume, either in absolute terms or relative to production or consumption in the United States, is significant. In examining the effect of the subject imports on prices, the U.S. ITC considers first whether there has been significant price underselling by the imports as compared with the price of domestic like products in the United States and whether the effect of those imports depresses prices or prevents price increases to a significant degree.

One of the analyses used by the U.S. ITC to judge injury is an economic model called the Commercial Policy Analysis System (COMPAS), which first seeks to isolate the impact of dumped imports on the domestic industry from other factors such as elasticities of supply, demand, and substitution in the U.S. market, market shares, and the U.S. DOC's dumping margin that may also be causing injury; and then determines whether the injury from dumped imports is material. In COMPAS, a hypothetical

scenario is constructed in which imports are not dumped. This allows comparison between the factual and counterfactual world to determine the extent to which dumped imports change prices and quantities in the domestic industry.

The U.S. DOC investigation involves the collection of information needed to calculate dumping margin for the products under investigation. The U.S. DOC issues questionnaires to the foreign producers (respondents) of the subject product, requesting information on their corporate structure, distribution, home market and U.S. sales,[9] accounting and finance practice, and the specification of the products. The period of investigation usually is the four fiscal quarters most recently completed before the filing of the antidumping petition,[10] although the period can vary by U.S. DOC discretion.

Within 140 days of initiating an antidumping investigation, the U.S. DOC must issue a preliminary determination as to whether there is a reasonable basis to believe or suspect that dumping is taking place. If the preliminary determination is affirmative, the U.S. DOC will order the suspension of liquidation of all entries of the subject imports and instruct the U.S. Customs Service to impose a bonding requirement on the subject imports in the amount of the estimated antidumping duties to ensure payment if duties ultimately are imposed. Regardless of whether the U.S. DOC's preliminary determination is affirmative or negative, the U.S. DOC must complete its investigation and issue a final determination.

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[9] The sales reports include from price, quantity, and customer name to a complete physical description of the product, and all relevant expenses associated with the sale.

[10] The period of investigation precedes the filing of the petition in order to ensure that foreign producers cannot artificially revise their pricing after the investigation begins to reduce their actual rated of dumping.

The U.S. DOC has limited authority to settle an antidumping investigation before completing the investigation. Section 734(a) of the Tariff Act of 1930 provides the U.S. DOC with the authority to terminate an investigation based on withdrawal of the petition pursuant to an agreement limiting the volume of imports into the United States. Section 734(b) provides the U.S. DOC the authority to suspend an investigation pursuant to an agreement with companies representing at least 85% exports to the United States that they will either cease dumping or cease exports to the United States. Such an agreement provides a mechanism whereby the U.S. DOC calculates normal values above which the signatories agree to sell their products in the United States. Section 734(c) provides the U.S. DOC with the authority to suspend an investigation pursuant to an agreement with companies representing at least 85% exports to the United States that will eliminate completely the injurious effect of their exports to the United States. Furthermore, such an elimination of injury agreement must prevent price suppression or undercutting of U.S. prices and eliminate at least 85% of the dumping margin found in the investigation. The U.S. DOC may enter into a suspension agreement only when there are extraordinary circumstances. Extraordinary circumstances are defined as meaning that the case is complex and that suspension would be more beneficial to the domestic industry than continuation of the investigation. Before entering into a suspension agreement, the U.S. DOC should determine that the suspension agreement can be monitored effectively and is in the public interest, pursuant to Section 734(d) of the Tariff Act of 1930. Absent affirmative determinations under a 5-year (or sunset) review,[11] the U.S. DOC expects to

[11] Sunset review: By the Uruguay Round Agreements Acts approved in 1994, the antidumping and countervailing duty laws were amended such that the U.S. DOC and ITC are required to conduct reviews no later than five years after an antidumping or countervailing duty order is issued, or a suspension agreement is entered, in order to determine whether revocation of the order or termination of the suspended

terminate the suspension agreement and the underlying investigation – no antidumping duty order is issued (ITA, 1996).

Between the preliminary and final determination, the U.S. DOC conducts a verification of the data submitted by respondents. Following verification, but prior to the final determination, both petitioners and respondents have an opportunity to submit briefs and participate in a public hearing. This is an opportunity for parties to make arguments regarding the U.S. DOC's interpretation of respondents' data and its analysis of those data.

If the U.S. DOC's preliminary determination is affirmative, the U.S. ITC commences its final investigation. In the case of a negative preliminary determination by the U.S. DOC, the U.S. ITC will not commence its final investigation unless and until there is an affirmative final determination by the U.S. DOC. If the U.S. DOC makes a final affirmative determination, the U.S. ITC is scheduled to make its final determination concerning injury within 45 days after the publication of the U.S. DOC's final determination. If both the U.S. DOC's and ITC's final determinations are affirmative, the U.S. DOC issues an antidumping duty order and publishes in the Federal Register (ITA, 2002b). The antidumping duty order directs the U.S. Customs Service to require U.S. importers to make cash deposits equal to the estimated antidumping duties.

Unlike Section 201, neither the President nor any federal agency may intervene against the affirmative determinations of the U.S. ITC and DOC. However, the U.S. DOC and ITC determinations may be appealed to the U.S. Court of International Trade (CIT) and the Court of Appeals for the Federal Circuit. An appeal to the U.S. CIT will only

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investigation would be likely to lead to continuation or recurrence of dumping or a countervailable subsidy and of material injury (ITA, 2001c; USITC, 2004).

succeed if the reviewing body finds that the Agency made an error of law in legal conclusions or that its decision was not supported by substantial evidence on the record for factual findings. In addition, international dispute resolution procedures are available. If the antidumping case involves a member country of the WTO, that member country may invoke the WTO's dispute settlement procedures. Also, under Chapter 19 of NAFTA, a case involving imports from Mexico or Canada may be appealed to a NAFTA Binational Panel consisting of five members drawn from a panel of experts and retired judges. The Binational Panel procedure is considerably more favorable to respondents than the U.S. CIT appeal process (Macrory, 1997).[12]

Countervailing Duty Law

A countervailing duty is an import charge imposed by one country to isolate itself from the effects of another country's subsidy (Finger, 1991). The countervailing duty law, Sections 701-709 of the Tariff Act of 1930, as amended, which is administered in the same way as the antidumping law, imposes additional duties on imports that are found to have benefited from certain types of government assistance that cause or threaten to cause material injury to a U.S. industry.

The U.S. ITC must determine whether there is a reasonable indication of material injury based on the information available to it at the time. The petitioner bears the burden of proof with respect to this issue (Bhala, 2001). The U.S. ITC must make affirmative or negative determination within 45 days of the date of filing of the petition or self-initiation. If the U.S. ITC makes an affirmative preliminary determination, the U.S. DOC must

[12] The Panels have been more willing to reverse decisions of the U.S. DOC than has the U.S. CIT. In addition, the Panels dispose of appeals faster than the U.S. CIT.

determine whether there is a reasonable basis to believe or suspect that a countervailing subsidy is being provided within 65 days after initiation of the investigation.

If affirmative, the U.S. DOC's preliminary determination should include an estimated amount of the net countervailable subsidy. The U.S. DOC orders the suspension of liquidation of all entries of foreign product subject to the investigation. Additionally, the U.S. DOC orders the posting of an appropriate security for each subsequent entry of the subject product equal to the amount of the net countervailable subsidy. The U.S. ITC begins its final injury investigation.

Unlike the antidumping law, the U.S. DOC can suspend a countervailing duty investigation on the basis of a quantitative restriction agreement limiting U.S. imports of the subject product.[13] When the U.S. DOC decides to suspend the investigation, it must publish notice of the suspension, and issue an affirmative preliminary subsidy determination. The U.S. ITC also suspends its investigation. If, within 20 days after the notice of suspension, the U.S. DOC receives a request for continuation of the investigation from a domestic interested party of from significant exporters, then both the U.S. DOC and ITC must continue their investigations.

The U.S. DOC issues a final subsidy determination within 75 days after the date of its preliminary determination. If there are simultaneous investigations under the antidumping and countervailing duty laws involving the same imports, the final countervailing determination may be postponed until the date of the final determination in the antidumping investigation at the request of a petitioner. If the final determination is negative, the investigation is terminated. If affirmative, the U.S. DOC awaits notice of the

[13] However, a countervailing duty investigation cannot be terminated based on quantitative restrictions.

U.S. ITC final injury determination. Within 120 days of a U.S. DOC affirmative preliminary determination or 45 days of a U.S. DOC affirmative final determination, the U.S. ITC must make a final determination of material injury. Figure 2-1 graphically shows the statutory processes of antidumping and countervailing duty investigations.

Within 7 days of notice of an affirmative final determination of the U.S. ITC, the U.S. DOC issues a countervailing duty order, which directs the U.S. Customs Services to assess countervailing duties equal to the amount of the net countervailing subsidy, describes the subject imports to which the countervailing duty applies, and requires the deposit of estimated countervailing duties at the same time as estimated normal custom duties are deposited.

Byrd Amendment

The Continued Dumping and Subsidy Offset Act (CDSOA) of 2000, known as Byrd Amendment,[14] was enacted on October 28, 2000. The CDSOA amended the U.S. Tariff Act of 1930 so that the U.S. Customs annually distributes duties to domestic producers who supported the petition for the antidumping or countervailing duty orders. Previously, the tariff revenue went directly into the general Treasury (eBearing.com). For a company (or producer) to be eligible for payouts, it must prove that it successfully litigated a dumping or countervailing duty case against a specific industry. Companies that did not participate in an original dumping or countervailing duty case do not receive any of the collected funds (Schmitz and Seale, 2003).

[14] While the CDSOA was originally authored by Senator DeWine (Ohio), it had failed to gather any significant support due to questioning about its legality under the WTO and NAFTA rules. Senator Byrd (West Virginia) added the CDSOA as Title X to the Agriculture Spending Bill of 2000 (eBearing.com; Schmitz and Seale, 2003).

The CDSOA took effect for 2001 and the first payouts were made late in 2001. However, the CDSOA caused an expected trade complaint to WTO. The complaint was brought by the European Union and eight other countries. It was the largest joint request ever filed in a WTO trade dispute case. On January 16, 2003 the Appellate Body of WTO confirmed that Byrd Amendment violates WTO rules. The United States was given until December 27, 2003 for its compliance with the WTO ruling. This deadline passed without action from Congress to repeal the measure (USEU, 2004).

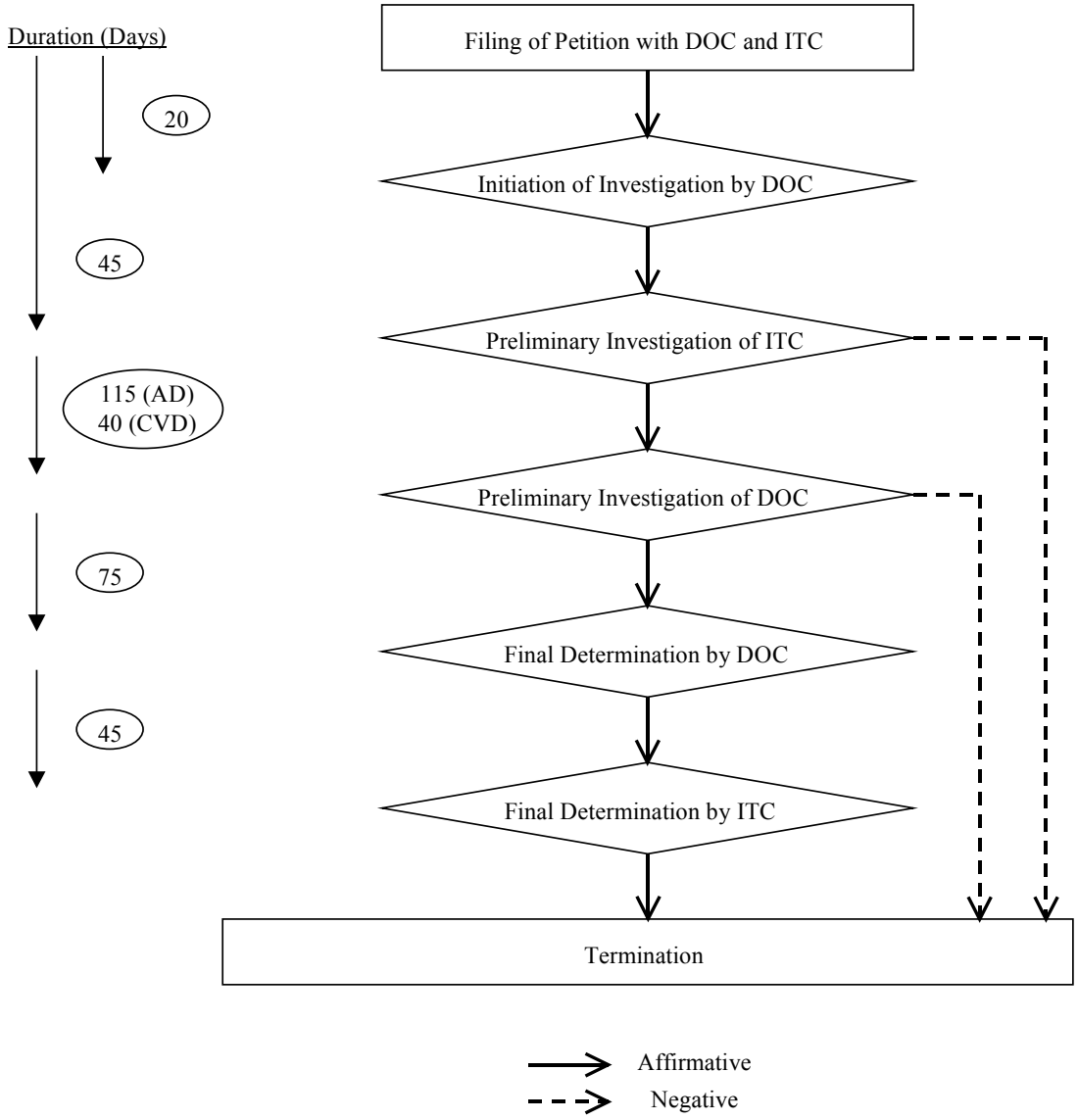

Figure 2-1. Procedures of antidumping (AD) and countervailing duty (CVD) order

CHAPTER 3
OVERVIEW OF U.S. FRESH TOMATO INDUSTRY

The U.S. fresh tomato industry has been growing significantly over the past several decades and is currently one of the world's leading fresh tomato producers. International trade is an important part of the U.S. fresh tomato industry. U.S. fresh tomato imports have risen sharply since 1994. This chapter provides the current industry condition of fresh tomatoes and describes a history of trade disputes on fresh tomatoes.

U.S. Fresh Tomato Industry

The increase in tomato production over the past 20 years is due to improved efficiency at the grower and processor levels. Different tomato varieties are grown specifically to meet the requirements of fresh tomato markets. Fresh tomatoes lead in farm value along with lettuce and potatoes, with a value of $1.9 billion in 2002, 12% of all vegetable and melon cash receipts.

Total harvested acreage for fresh tomatoes has decreased from 147,100 acres in 1970 to 124,900 acres in 2002, however yields per acre have been increasing from 124 hundred weight to 299 hundred weight over the same period. U.S. fresh tomato production steadily increased until peaking in 1992. Production then trended downward until rising again in 1999 (Figure 3-1). The U.S. grower price for fresh tomatoes in 2002 was $0.32 per pound, while the retail price was $1.33 per pound. Table 3-1 indicates that the retail price of fresh tomatoes is linked to the grower price, averaging about 26% of the retail price. The difference between those two prices includes marketing costs such as wages, transportation, and packing.

California and Florida account for two-thirds of the acres used to grow fresh tomatoes in the United States. Florida is the largest domestic source of fresh tomatoes. Florida produced 39% of the domestic U.S. production in 2002, increasing from 28% in 1970. In Florida, October to June of the following year is the season for tomato production. During the colder winter months, most tomatoes come from south Florida (Dade County and Collier County), with warm spring weather moving production north (from Manatee County to Gadsden County). California accounted for 31% of domestic production in 2002 with one-third of that crop produced in San Diego and Fresno Counties.

Production of greenhouse fresh tomatoes comprises 5% of total fresh tomato production in 2000 with a trend of growth.[1] Greenhouse tomatoes were initially imported from the Netherlands and marketed on-vine (i.e., cluster tomatoes) to provide a fresh appearance to consumers. While field-grown tomatoes are picked when still entirely green, most greenhouse tomatoes are harvested during the ripening process as the tomatoes begin to show color. Greenhouse tomatoes are regarded as having superior appearance and taste compared to field-grown tomatoes. In addition, greenhouse tomatoes tend to use fewer pesticides.

Tomatoes are the third most widely consumed vegetable in the United States, ranking behind potatoes and lettuce. Fresh tomato consumption has continuously increased over the past three decades (Figure 3-2). During the recent 3 years (2000-02), average fresh tomato consumption increased 46% over the 1970's average consumption

[1] In 2000, domestic greenhouse tomatoes production totaled 183 million pounds, an increase of 27% from 1998. The production quantities of fresh tomatoes were 3,674 million pounds in 2000. Source: Economic Research Service, USDA (ERS, 2002) and U.S. International Trade Commission (USITC, 2001).

to 17.8 pounds per person annually. The increase in consumption is likely the result of increased consumers' awareness of health and nutrition benefits from eating more tomatoes. As a good source of vitamins A and C and lycopene, fresh tomatoes are known to reduce risk of various cancers and heart disease.

Current Trends of U.S. Fresh Tomato Trade

As a net importer of fresh tomatoes, the United States imported 36% of total fresh tomato consumption in 2002, while the United States exported 9% of total domestic production. Canada is the primary country for the U.S. fresh tomato exports. Canada accounted for 84% of the total fresh tomato exports in 2002 followed by 11% to Mexico and less than 1% to Japan and United Kingdom. Fresh tomato exports to Japan are expanding since the market recently opened to U.S. tomato shippers with the removal of phytosanitary restrictions in 1997.

In 2001, Mexico supplied 67% of the import value of fresh tomatoes followed by Canada (23%), and the Netherlands (7%). The quantity imported from Mexico increased steadily and surged in 1995 due to a devaluation of Mexican peso. Recently, imports from Canada have increased due to rising sales of greenhouse products (Figure 3-3). The quantity of greenhouse tomato imports from Canada increased from 95.2 million pounds in 1999 to 233.6 million pounds in 2001. Generally, the United States imports most fresh tomatoes in the late-fall to early-spring period when domestic supplies are low.

Imports from Mexico peak in the winter months when south Florida is the major producer. Competition in the winter fresh tomato market has resulted in numerous cases of trade disputes being filed between the United States and Mexico since 1978.[2] Under

[2] The first antidumping petition was filed by Florida fresh tomato producers losing the market share as a result of the increased shipments from Mexico (VanSickle, 2003).

the North American Free Trade Agreement (NAFTA), some tariffs for fresh tomato imports from Mexico were eliminated over the first 5 years of the Agreement (1994 to 1998), while other tariffs were phased out over the 10-year transition periods 1994 to 2003. The 10-year phase-out was applied to imports from March 1 to July 14 and November 15 to the end of February with a tariff-rate-quota (TRQ) also placed into effect as well. Under the TRQ, if tomato imports exceed the quota, the over-quota volume is assessed the most favored nation (MFN) tariff rate. The tariff on fresh tomato imports from Canada fell to zero in 1998.

Fresh Tomatoes from Mexico

On March 29, 1995, a petition was filed with the U.S. International Trade Commission (ITC) on behalf of the Florida Tomato Exchange seeking relief from increased imports of fresh winter tomatoes from Mexico under Section 201 of the U.S. Trade Act of 1974 (USITC, 1995).[3] It was the first petition filed with the U.S. ITC to provisional relief with respect to a perishable agricultural product. The petitioner asked that the U.S. ITC make an affirmative determination on the basis of imports entering during only the first 4 months of the year, but not all 12 months of the year urging the U.S. ITC to find a domestic industry to consist only of those producers who produce during that 4-month period. Petitioners asserted that the relevant domestic industry consists of those growers and packers who grow and ship fresh tomatoes (excluding cherry and greenhouse tomatoes) sold during the months of January through April. However, the respondent representing the principal Mexican growing area argued that the

[3] A Section 201 petition allows producers to seek relief from increased imports that cause *serious injury*. Criteria for import relief are based on GATT Article XIX also referred as Escape Clause.

concept of a fresh winter tomato industry during the months of January through April is an artificial construct.

On April 10, 1995, the U.S. ITC made a negative injury and provisional relief determination. The U.S. ITC found that there was no separate fresh winter tomato industry and the U.S. domestic industry should include all growers and packers during the full calendar year; and that there was no basis for concluding that cherry tomatoes and tomatoes grown in greenhouses are distinguishable from field-grown tomatoes. The available data showed that imports over a 4-5 year period, whether viewed on a full-year basis or in terms of the 4-month period, had increased, but only marginally. The limited available facts also showed an upward trend in fresh tomato production and productivity in the United States over the period of investigation. Since petitioner requested provisional relief only through April 30 – even if the U.S. ITC made an affirmative injury determination – relief of such short duration would likely have little or no impact on overall import levels and be of little benefit to the industry. On May 4, 1995, the petitioner subsequently withdrew the petition and the U.S. ITC terminated the investigation without a final determination.

On March 11, 1996, another Section 201 petition was filed by several groups of fresh tomato and bell pepper growers and packers in Florida alleging that the U.S. domestic fresh tomato and bell pepper industries were seriously injured or threatened with serious injury by reason of increased imports from Mexico (USITC, 1996a). About the same time, the U.S. ITC and Department of Commerce (DOC) instituted antidumping investigation in response to a petition filed by representatives of the U.S. fresh tomato industry alleging that an industry in the United States is materially injured or threatened

with material injury by reason of less than fair value imports of fresh tomatoes from Mexico on April 4, 1996 and April 25, 1996, respectively (USITC, 1996b and 1997). The U.S. DOC defined the imported articles subject to this investigation as all fresh or chilled tomatoes except for those that are for processing.[4]

The debatable issue in this antidumping investigation was whether mature green and vine ripe tomatoes constitute separate domestic like products. Petitioner in the United States argued that there is a single domestic like product consisting of all fresh tomatoes, whether mature green or vine ripe. Respondents from Mexico argued that mature green fresh tomatoes and vine ripe fresh tomatoes are separate domestic like product. Most domestic growers use varieties of tomato seeds bred to be harvested as mature greens, but harvest some portion of the crop vine ripe. Since domestic producers grow mature green and vine ripe tomatoes on the same plants, there is virtually no difference in fertilization or irrigation. The principal differences in the production process occur during and after harvest. As described before, mature green tomatoes are harvested when they are fully mature in size but still entirely green in color and then degreened through the use of ethylene gas. Vine ripe tomatoes are allowed to ripen to a moderate color on the vine prior to harvest. However, at the retail level, fresh tomatoes whether mature green or vine ripe have the same general physical appearance so that a grocery store customer generally would not be able to tell the difference between a mature green and vine ripe based on its physical appearance. The U.S. ITC also noted that vine ripe and mature green tomatoes are interchangeable in many applications, are sold in the same channels of distribution.

[4] Fresh tomatoes in this antidumping investigation included common round, Roma (also called plum or pear), and cherry tomatoes, which are generally grown in fields but are also grown in greenhouses (greenhouse and hydroponic tomatoes).

For the comparison of prices of mature greens and vine ripes, the U.S. ITC gathered separate pricing data. Those data suggested that there is no consistent or significant price premium for vine ripes. In sum, this antidumping preliminary investigation did not demonstrate a clear dividing line between mature green and vine ripe tomatoes and found a single domestic like product consisting of all fresh market tomatoes. In Section 201 investigation in 1996, the U.S. ITC found that domestic mature greens are like or directly competitive with imported vine ripe tomatoes and also that domestic fresh tomatoes are like or directly competitive with imported greenhouse tomatoes.

In both the preliminary antidumping investigation and Section 201 case, the U.S. ITC determined that both growers and packers should be included in the domestic industry showing that there is a single line of continuous production involving both growers and packers and some coincidence of economic interest between growers and packers. Some growers own their own packing operations, and some packers also grow or finance or engage in crop sharing programs with growers. Based on grower's questionnaire responses, over 87% of domestic production in 1995 was shipped to related packers indicating that there is a substantial degree of vertical integration between growers and packers in the domestic tomato industry (USITC, 1996b).

In May 1996, the U.S. ITC made an affirmative determination in this preliminary antidumping investigation that there is a reasonable indication that the domestic industry producing fresh tomatoes is materially injured by reason of allegedly LTFV imports from Mexico. On July 2, 1996, however, the U.S. ITC made a negative injury determination that even though imports of fresh tomatoes and bell peppers have increased, the domestic

fresh tomato and bell pepper industries are not seriously injured or threatened with serious injury. As a result, no relief was provided.

After the U.S. DOC's announcement in October 1996 of a preliminary finding of dumping margins ranging from 4.16% to 188.45% and its determination that imports of fresh tomatoes from Mexico are being sold at LTFV in the United States, the U.S. DOC and Mexican growers of fresh tomatoes entered into a suspension agreement wherein each signatory producer agreed to revise its prices to eliminate completely injurious effects of exports of fresh tomatoes to the United States (ITA, 1996). The suspension agreement took effect on November 1, 1996. To ensure that there will be no undercutting or suppression of prices, the agreement sets a reference price,[5] which can be adjusted after one year if market conditions undergo significant changes.[6]

On October 1, 2001, the U.S. DOC initiated a five-year sunset review of the suspension agreement. As a result of this review, on January 29, 2002, the U.S. DOC preliminary finds that termination of the suspended antidumping duty investigation on fresh tomatoes from Mexico would be likely to lead to continuation or recurrence of dumping (ITA, 2002c).

On May 31, 2002, Mexican tomato growers submitted to the U.S. DOC a notice of their withdrawal from the agreement suspending the antidumping investigation. Since the suspension agreement would no longer cover substantially all imports of fresh tomatoes from Mexico if the withdrawals became effective, on July 30, 2002, the U.S. DOC

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[5] The reference price established in the October 28, 1996 Suspension Agreement was the f.o.b. price, U.S. port of entry at the Mexican border, from the first importer to an unaffiliated purchaser, which was $0.2068 per pound (ITA, 1997).

[6] On August 6, 1998, the suspension agreement was amended by the establishment of a second reference price and the time periods during which each reference price is applicable (ITA, 1998).

terminated the suspension agreement and the sunset review, and resumed the antidumping investigation (ITA, 2002b).[7]

Currently, a new suspension agreement is effective since December 16, 2002 when the U.S. DOC has again suspended the antidumping investigation based upon an agreement between the U.S. DOC and Mexican producers wherein each signatory producer has agreed to revise its prices to eliminate completely the injurious effects of exports of fresh tomatoes to the United States (ITA, 2002d).

Greenhouse Tomatoes from Canada

The implementation of NAFTA preceded disputes related to fresh tomato trades with Canada as well as Mexico. On March 28, 2001, a group of six U.S. greenhouse tomato growers filed an antidumping petition with the U.S. ITC and DOC, alleging that the U.S. domestic industry was materially injured, or threatened with material injury by reason of dumped imports of greenhouse tomatoes from Canada (ITA, 2001a; USITC, 2001). The domestic like product in the preliminary antidumping investigation included only tomatoes grown in greenhouses. The U.S. ITC made an affirmative preliminary injury determination and the U.S. DOC preliminary determined that greenhouse tomatoes from Canada are being, or are likely to be, sold in the United States at LTFV prices in May 2001 and October 2001, respectively (ITA, 2001d). In its amended preliminary determination, the U.S. DOC revised dumping margins ranging from 24.04% to 33.95% (ITA, 2001b). Along the U.S. DOC's final determination of sales at LTFV of Feb 26, 2002, however, the U.S. ITC made a final negative determination that the U.S. domestic industry was not materially injured by reason of imports of Canadian greenhouse

[7] The U.S. DOC resumed the investigation as if it has published the affirmative preliminary determination on July 30, 2002.

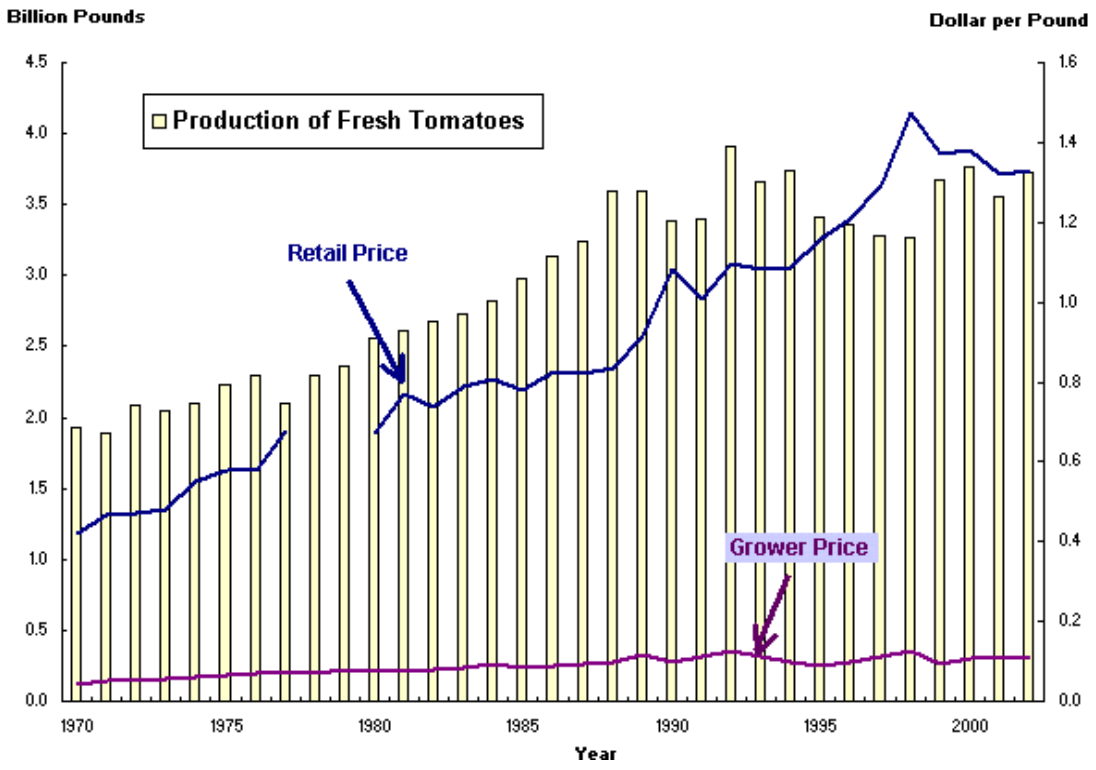
tomatoes in April 2002 and no antidumping duty order was issued (ITA, 2002a; USITC, 2002b).

In the mean time, the Canadian Tomato Trade Alliance (CTTA) filed an antidumping complaint with the government of Canada against U.S. fresh tomato imports on June 28, 2001. The CTTA alleged that field-grown tomatoes from Florida and California are being sold in Canada at 30% to 50% below the cost of production, jeopardizing the future of Canadian greenhouse-grown tomatoes (AgJournal.com, 2001). In its preliminary determination of March 25, 2002, the Canadian International Trade Tribunal (CITT) determined that there was a reasonable indication that the dumping had caused injury to the domestic industry. However, on June 24, 2002, the CITT issued a final determination that fresh tomatoes from the United States did not cause material injury to the Canadian domestic industry (CITT, 2002).

Table 3-1. United States fresh tomatoes: Average grower and retail price (dollar per pound) from 1970 to 2002

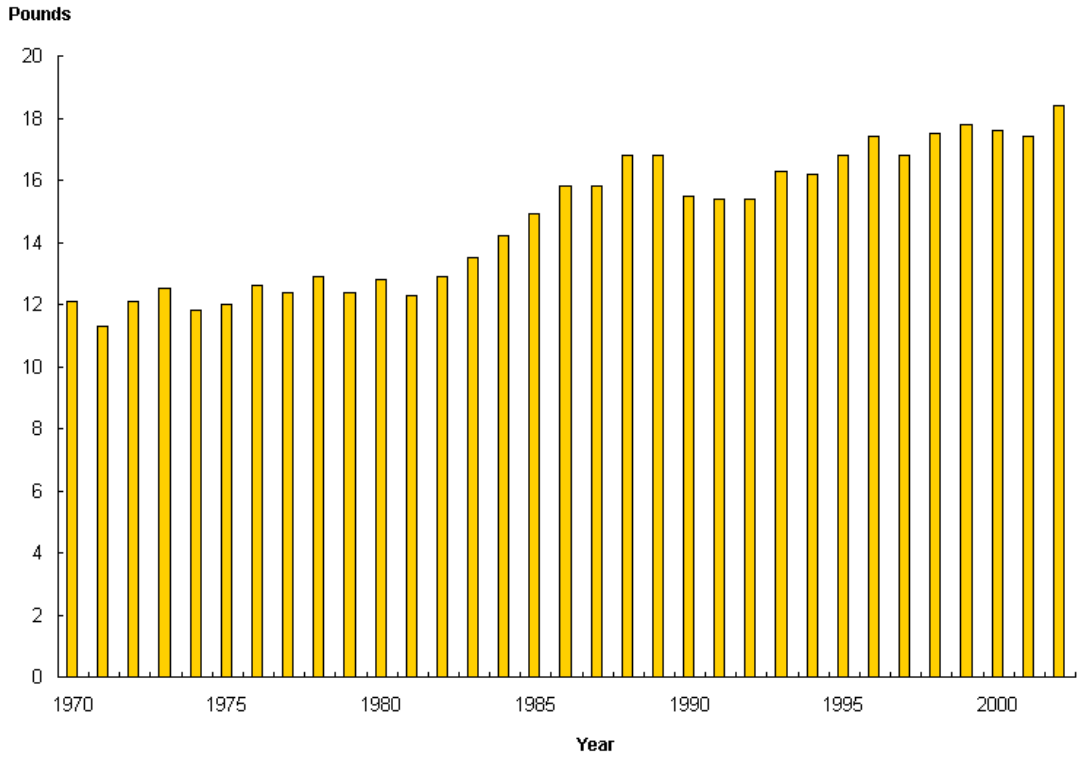
Year	Grower	Retail
1970	0.11	0.42
1975	0.19	0.58
1980	0.21	0.67
1985	0.24	0.78
1990	0.27	1.08
1991	0.32	1.01
1992	0.36	1.09
1993	0.32	1.08
1994	0.27	1.09
1995	0.26	1.16
1996	0.28	1.21
1997	0.32	1.29
1998	0.35	1.48
1999	0.26	1.37
2000	0.31	1.38
2001	0.30	1.32
2002	0.32	1.33

Source: Economic Research Service, USDA (ERS, 2003b).



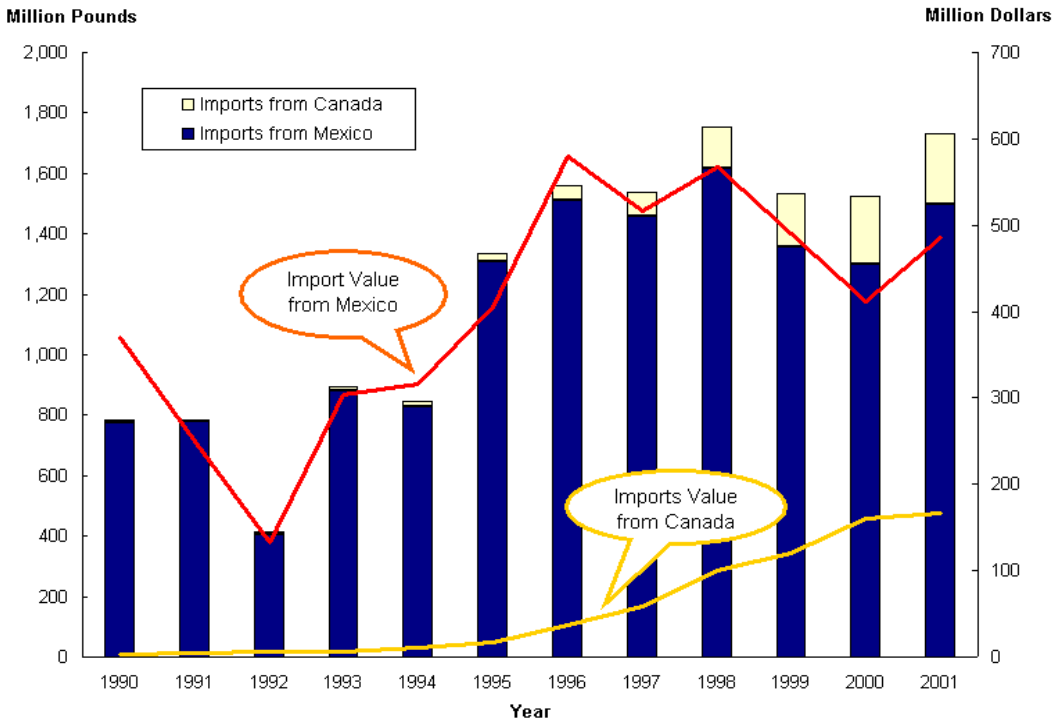
Source: Economic Research Service, USDA (ERS, 2003b).
(Not available for retail price data from 1978 to 1979.)

Figure 3-1. United States fresh tomatoes: Grower and retail price and production (1970-2002)



Source: Economic Research Service, USDA (ERS, 2003a).

Figure 3-2. United States fresh tomatoes: Per capita consumption (1970-2002)



Source: Economic Research Service, USDA (ERS, 2003b).

Figure 3-3. United States fresh tomatoes: Exports and imports (1990-2002)

CHAPTER 4
COMMERCIAL POLICY ANALYSIS SYSTEM (COMPAS)

Commercial Policy Analysis System (COMPAS) is an economic model used by the U.S. International Trade Commission (ITC) for the purpose of analyzing trade-related injury or gains to specific domestic industries and the overall domestic economy as a result of industry-specific trade policy changes (Francois and Hall, 1993). This chapter describes the fundamental structure and characteristics of COMPAS. Furthermore, economic analyses of unfair trade are presented in terms of the COMPAS framework.

Model Structure

COMPAS is a package of standardized spreadsheets developed for the analysis of specific trade policy changes including unfair trade remedies of dumping or subsidies and fair trade (global safeguard) tariff rate changes. The COMPAS spreadsheets are designed to run on IBM-compatible computers that have Quattro, Quattro Pro, or Microsoft Excel.[1] Each spreadsheet requires certain user-provided data. The data necessary to operationalize the model are entered in a section of the spreadsheet titled "INPUTS". Once the input data have been provided, the results of the COMPAS analysis are shown in the section of the spreadsheet titled "RESULTS". Figure 4-1 is an example view captured from the COMPAS spreadsheet windows. The underlying model structure of COMPAS is an imperfect substitute models also known as the Armington model. Armington Model

[1] COMPAS is a shareware and can be freely distributed.

Armington (1969) presented a theory of demand for products that are distinguished not only by their kind but also by their country of origin. Therefore, products that were produced at different places are distinguished from one another in the sense that they are assumed to be imperfect substitutes in demand. Assuming that (1) import demands are separable among import sources (i.e., separability assumption), (2) elasticities of substitution between all pairs of products within a group are constant (i.e., Constant-Elasticity-of-Substitution (CES) assumption), and (3) the size of the market does not affect each country's market share (i.e., homotheticity assumption), Armington specified the demand for a good *A* imported from *j*, M_j as the following:

$$M_j = b_j^{\sigma} M \left(\frac{p_j}{P} \right)^{-\sigma} \qquad j = 1,2,...,n \qquad (4\text{-}1)$$

where b_j is a constant, σ denotes a single CES, M is total import demand for the good *A*, p_j is the price of the good *A* imported from country *j*, and P is the price index.

In consumer theory, consumers are assumed to allocate their total expenditures in two stages (i.e., two-stage budgeting procedure). In the first stage, total expenditure is allocated over broad groups of goods. In the second stage, group expenditures are allocated over individual goods within each group (Deaton and Muellbauer, 1980b). The Armington model can be explained in the context of the two-stage budgeting procedure: In the first stage (Equation (4-2)), the importer decides how much of a particular commodity – the good *A* – to import, while in the second stage (Equation (4-3)), given the total amount imported, the importer decides how much to import from each country.

$$M = f(Y, P, P_O) \qquad (4\text{-}2)$$

$$M_j = g(M, P, p_j) \qquad j = 1,2,...,n \qquad (4\text{-}3)$$

where Y is total expenditure and P_O is a vector of the prices of all other goods.[2] Equation (4-1) is the Armington model that imposes the CES functional form on Equation (4-3) implying separability between different import sources (Alston et al., 1990).

The Armington model in Equation (4-1) can be expressed as a share function by dividing both sides by M and multiplying by (p_j/P):

$$\frac{p_j M_j}{PM} = b_j^{\sigma}\left(\frac{p_j}{P}\right)^{1-\sigma} \tag{4-4}$$

Taking the logarithm of Equation (4-4) yields the Armington model in a market share form:

$$\log w_j = \sigma \log b_j + (1-\sigma)\log\left(\frac{p_j}{P}\right) \qquad j = 1,2,...,n \tag{4-5}$$

where $w_j = p_j M_j / PM$, which denotes the market share of imports from source *j*. No expenditure term in the right hand side in Equation (4-5) implies homotheticity assumption. That is, the change in importer's expenditure does not affect the market share (Yang and Koo, 1993). As a result, all expenditure elasticities within a group are equal and unitary and import market shares change only in response to relative price changes.

The Armington model is a popular specification for the empirical analysis of trade policy changes. The approach is flexible and it allows the calculation of cross-price elasticities between imports from different sources using estimates of the aggregate price elasticity of demand for imports, a single CES, and market shares. Additionally,

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[2] That is, $P_O = \sum_k p_k$. *k* denotes all other good excluding the price of good *A*.

multicollinearity can be reduced with theoretical justification due to separability assumption (Babula, 1987).

However, the Armington assumptions of separability, homotheticity, and single CES are strong restrictions for practical application. The separability assumption omits prices of substitutes which are likely to be correlated with the own-price elasticity (i.e., positive cross-price elasticities). When prices of substitutes – relevant explanatory variables – are omitted, the own-price parameter estimates are positively biased so that the own-price elasticities would be underestimated (Kmenta, 1997). Although the homotheticity assumption simplifies the model specification, if a good is differentiated, a change in the buyer's budget may not be allocated in the same proportion to all products. If an increase in the budget is realized, it would be allocated more to the more preferred product. In other words, expenditure elasticities may not be unitary. The single CES assumption restricts responses of the import demand of each product to the price change relative to the price index for the good to be the same for all products. What if elasticities of substitution are not the same between any pair of products?

If data do not satisfy the Armington assumptions, the Armington model may give biased elasticity estimates. Several empirical studies applying the Armington model to the agricultural trade analysis showed that the Armington assumptions were rejected for their data (Alston et al., 1990; Moschini et al, 1994; Seale et al., 1992; Weatherspoon and Seale, 1995; Winters, 1984; Yang and Koo, 1993). In these cases, a less restrictive set of assumptions on demand relationship than those of the Armington model should be applied (Yang and Koo, 1993).

Armington Elasticity – Elasticity of Substitution

Using an economic model in order to evaluate changes in trade policy requires the conversion of policy changes into price effect determining how a certain policy affects output, employment, trade flows, economic welfare, and other variables (McDaniel and Balistreri, 2002). The direction and magnitude of a trade policy change on individual variables depends on the degree of substitution between imported and domestic goods (i.e., the elasticity of substitution also known as Armington elasticity). The elasticity of substitution is defined as the proportionate change in the relative quantities from two competing suppliers – domestic and imports or two different importing countries – divided by the proportionate change in their prices (Blandford, 1988). The higher the value of Armington elasticity, the closer is the degree of substitution. Imports and domestic products are considered by consumers to be identical and strong substitutes if the elasticity of substitution is infinite (Kapuscinski and Warr, 1996).

The Armington elasticity is a key behavioral parameter in trade policy analysis. de Melo and Robinson (1981) show how the degree of substitution affects the domestic price effects of changes in tariff in Armington structure. A CES function of imports M, and domestic products, D can be written as

$$Q = \phi(M, D) = \left[\delta M^{-\rho} + (1-\delta) D^{-\rho}\right]^{-\frac{1}{\rho}} \tag{4-6}$$

where Q denotes composite commodity of the domestic good, D and imports, M.[3] δ and ρ are constants. From Equation (4-6), each demand function of M and D can be

[3] Here, the composite good, Q consists of imports and domestic product

derived. Based on the theory of the utility-maximizing consumer, we know that the marginal rate of substitution between two goods must equal the ratios of their prices:

$$\frac{\frac{\partial \phi}{\partial M}}{\frac{\partial \phi}{\partial D}} = \frac{\delta}{1-\delta}\left(\frac{D}{M}\right)^{1+\rho} = \frac{p_M}{p_D} \tag{4-7}$$

where p_M and p_D are prices of imports and domestic good, respectively. Solving Equation (4-7) for M and D, respectively,

$$M = D\left(\frac{\delta p_D}{(1-\delta)p_M}\right)^{\frac{1}{1+\rho}} \tag{4-8}$$

$$D = M\left(\frac{(1-\delta)p_M}{\delta p_D}\right)^{\frac{1}{1+\rho}} \tag{4-9}$$

Equation (4-8) can be written in terms of elasticity of substitution:

$$\frac{M}{D} = \left(\frac{1-\delta}{\delta}\right)^{-\sigma}\left(\frac{p_M}{p_D}\right)^{-\sigma} \tag{4-10}$$

where $\sigma = \frac{1}{1+\rho}$, which denotes the elasticity of substitution since by definition (Varian, 1992). That is, the elasticity of substitution between M and D is

$$\begin{aligned}\sigma &= -\frac{\Delta\left(\frac{M}{D}\right)\Big/\left(\frac{M}{D}\right)}{\Delta\left(\frac{\partial\phi/\partial M}{\partial\phi/\partial D}\right)\Big/\left(\frac{\partial\phi/\partial M}{\partial\phi/\partial D}\right)} = -\frac{\partial\left(\frac{M}{D}\right)\Big/\left(\frac{M}{D}\right)}{\partial\left(\frac{p_M}{p_D}\right)\Big/\left(\frac{p_M}{p_D}\right)} \\ &= -\frac{d\ln(M/D)}{d\ln(p_M/p_D)} = \frac{1}{1+\rho}\end{aligned} \tag{4-11}$$

Substituting Equation (4-9) into Equation (4-6) and solving for M,

$$Q = \delta^{-\sigma} M\left[\delta^{\sigma} + (1-\delta)^{\sigma}\left(\frac{p_M}{p_D}\right)^{\sigma-1}\right]^{\frac{\sigma}{\sigma-1}} \tag{4-12}$$

$$M = \delta^{\sigma} Q \left[\delta^{\sigma} + (1-\delta)^{\sigma} \left(\frac{p_M}{p_D} \right)^{\sigma-1} \right]^{\frac{\sigma}{1-\sigma}} \tag{4-13}$$

Similarly, substituting Equation (4-8) into Equation (4-6) and solving for D,

$$Q = (1-\delta)^{-\sigma} D \left[\delta^{\sigma} \left(\frac{p_M}{p_D} \right)^{\sigma-1} + (1-\delta)^{\sigma} \right]^{\frac{\sigma}{\sigma-1}} \tag{4-14}$$

$$D = (1-\delta)^{\sigma} Q \left[\delta^{\sigma} \left(\frac{p_M}{p_D} \right)^{\sigma-1} + (1-\delta)^{\sigma} \right]^{\frac{\sigma}{1-\sigma}} \tag{4-15}$$

Rewriting Equation (4-7),

$$\frac{p_M}{\partial\phi/\partial M} = \frac{p_D}{\partial\phi/\partial D} = P \tag{4-16}$$

where P is the average price level in the market or the price for the composite goods. Solving Equation (4-16) for P,

$$P = p_M \delta^{-1} M^{\frac{1}{\sigma}} Q^{-\frac{1}{\sigma}} \quad \text{or} \tag{4-17}$$

$$P = p_D (1-\delta)^{-1} D^{\frac{1}{\sigma}} Q^{-\frac{1}{\sigma}} \tag{4-18}$$

Again, substituting Equation (4-13) into Equation (4-17), then P can be expressed as a function of p_M and p_D:

$$P = \left[\delta^{\sigma} p_M{}^{1-\sigma} + (1-\delta)^{\sigma} p_D{}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{4-19}$$

Substituting Equation (4-12) into Equation (4-17),

$$\frac{p_M}{P} = \left[\delta^{\sigma} + (1-\delta)^{\sigma} \left(\frac{p_M}{p_D} \right)^{\sigma-1} \right]^{\frac{1}{1-\sigma}} \tag{4-20}$$

Substituting Equation (4-20) into Equation (4-13),

$$M = M(p_M, P, Q) = \delta^{\sigma} Q \left(\frac{p_M}{P} \right)^{-\sigma} \tag{4-21}$$

Likewise, Equation (4-15) can be rewritten as

$$D = D(p_D, P, Q) = (1-\delta)^{\sigma} Q \left(\frac{p_D}{P} \right)^{-\sigma} \tag{4-22}$$ [4]

Now, the effect of a policy-induced change in the import price, p_M, on the demand for the domestic good, D, can be explained by the following equation.

$$\begin{aligned} \frac{\partial D}{\partial p_M} &= \left(\frac{\partial D}{\partial P} + \frac{\partial D}{\partial Q} \frac{\partial Q}{\partial P} \right) \frac{\partial P}{\partial p_M} \\ &= \left[\sigma \left(\frac{D}{P} \right) + \frac{D}{Q} \left(-\varepsilon_Q \frac{Q}{P} \right) \right] \delta^{\sigma} \left(\frac{P}{p_M} \right)^{\sigma} \\ &= \frac{D}{P} \left(\sigma - \varepsilon_Q \right) \delta^{\sigma} \left(\frac{P}{p_M} \right)^{\sigma} \end{aligned} \tag{4-23}$$

where ε_Q is the price elasticity of demand for the composite good. Equation (4-23) implies that a change in the import price affects the demand for the domestic good through the effect on the composite price and the demand for the composite goods. It is necessary to define an equilibrium condition which is

$$D = S \tag{4-24}$$

Under traditional partial equilibrium assumptions, the demand of the domestically produced good, D, will be a function of both the domestic price of that good, p_D and the import price of the foreign produced good of the same group, p_M, while the supply, S, of the domestic good is a function of its own price:

$$D = D(p_D, p_M) \qquad S = S(p_D) \tag{4-25}$$

[4] Equations (4-21) and (4-22) are equivalent to Equation (4-1).

Totally differentiating Equation (4-24),

$$\frac{\partial D}{\partial p_D} dp_D + \frac{\partial D}{\partial p_M} dp_M = \frac{\partial S}{\partial p_D} dp_D \tag{4-26}$$

Rewriting Equation (4-26),

$$\frac{dp_D}{dp_M} = \frac{\partial D / \partial p_M}{\partial S / \partial p_D - \partial D / \partial p_D} \tag{4-27}$$

Equation (4-27) describes how the domestic price is affected by a change in the import price resulted from a change in the tariff on imports. Substituting Equation (4-23) into Equation (4-27),

$$\frac{dp_D}{dp_M} = \frac{\frac{D}{P}(\sigma - \varepsilon_Q)\delta^{\sigma}\left(\frac{P}{p_M}\right)^{\sigma-1}}{\varphi_D\left(\frac{D}{p_D}\right) - \left[\frac{D}{P}(\sigma - \varepsilon_Q)(1-\delta)^{\sigma}\left(\frac{P}{p_D}\right)^{\sigma} - \sigma\left(\frac{D}{p_D}\right)\right]} \tag{4-28}$$

where φ_D is the elasticity of supply of the domestic product.[5] Multiplying both sides by $\frac{p_M}{p_D}$, Equation (4-28) can be expressed in terms of elasticity, *E*:

$$\frac{dp_D}{dp_M}\frac{p_M}{p_D} = \frac{\frac{D}{P}(\sigma - \varepsilon_Q)\delta^{\sigma}\left(\frac{P}{p_M}\right)^{\sigma-1}}{\varphi_D\left(\frac{D}{p_D}\right) - \frac{D}{P}(\sigma - \varepsilon_Q)(1-\delta)^{\sigma}\left(\frac{P}{p_D}\right)^{\sigma} + \sigma\left(\frac{D}{p_D}\right)}\frac{p_M}{p_D}$$

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[5] $\frac{\partial S}{\partial p_D} = \varphi_D\left(\frac{S}{p_D}\right) = \varphi_D\left(\frac{D}{p_D}\right)$ since $D = S$ from Equation (4-24), equilibrium condition. $\frac{\partial D}{\partial p_D} = \left[\frac{\partial D}{\partial P} + \frac{\partial D}{\partial Q}\frac{\partial Q}{\partial P}\right]\frac{\partial P}{\partial p_D} + \frac{\partial D}{\partial p_D}$, implying the effect of a change in the domestic price on the demand for the domestic good.

$$E = \frac{(\sigma - \varepsilon_Q)\delta^\sigma \left(\frac{P}{p_M}\right)^{\sigma-1}}{\varphi_D - (\sigma - \varepsilon_Q)(1-\delta)^\sigma \left(\frac{P}{p_D}\right)^{\sigma-1} + \sigma}$$

$$= \frac{(\sigma - \varepsilon_Q)\delta^\sigma \left(\frac{P}{p_M}\right)^{\sigma-1}}{(\varphi_D + \sigma) - (\sigma - \varepsilon_Q)(1-\delta)^\sigma \left(\frac{P}{p_D}\right)^{\sigma-1}} \tag{4-29}$$

where E denotes the domestic price response elasticity. This elasticity measures the partial equilibrium impact of a tariff change on the price of the domestic good since a tariff increases the import price.

Equation (4-29) can be written in terms of the import share. Since total expenditure on the composite good must equal the sum of expenditures on the domestic good and imported good, the following equation is true:

$$PQ = p_M M + p_D D \tag{4-30}$$

Then, the import share of total expenditure, w_M, can be written as

$$w_M = \frac{p_M M}{PQ} = \delta^\sigma \left(\frac{P}{p_M}\right)^{\sigma-1} \tag{4-31}$$

Rewriting Equation (4-29),

$$E = \frac{(\sigma - \varepsilon_Q) w_M}{(\varphi_D + \sigma) - (\sigma - \varepsilon_Q) w_D} = \frac{(\sigma - \varepsilon_Q) w_M}{\varphi_D + \varepsilon_Q + (\sigma - \varepsilon_Q) w_M} \tag{4-32}$$

where $w_D = (p_D D / PQ) = (1 - w_M)$. It shows that the value of E depends significantly on the import share. In addition, Equation (4-32) can be rewritten as

$$E = \frac{\varepsilon_{DM}}{\varphi_D + \varepsilon_Q + \varepsilon_{DM}} \tag{4-33}$$

where ε_{DM} is the cross-price elasticity of demand for the domestic good with respect to the import price. de Melo and Robison (1985) compare the value of E for various values of import shares and elasticities of substitution. When the import share is low, E is very low, even when the elasticity of substitution is high. Also, when the import share is very high and the elasticity of substitution is very high (e.g., $\sigma = 100$), the value of E is still less than one that would happen in perfect substitute cases. This indicates that in a large country with a low trade share, domestic prices would not be affected by a change in import prices even if the elasticity of substitution were very high. Conditions of supply and demand in the domestic market influence the value of E: The higher the elasticity of domestic supply, φ_D, the lower is E. If the elasticity of substitution is equal to the price elasticity of demand for the composite good, ε_Q, then $E = 0$ in Equation (4-32). In this case, a change in import price leads to a change in composite price and a change in demand for the composite good such that demand for the domestic good remains the same. If $\sigma = 0$, that is, the domestic and imported goods are perfect complements, decreasing the price of the imported good will raise the demand for the domestic good. This effect will occur also when the elasticity of substitution is lower than the price elasticity of demand for the aggregate good. The authors argue that the Armington specification of separability may imply too much autonomy for the domestic system and, therefore, the small welfare gains from reducing tariff.

Francois and Hall (1997) indicate that the results generated by the Armington structure are particularly sensitive to the value of the elasticity of substitution. They argue that as an imperfect substitute framework is considered, the impact of protection on the domestic industry is substantially less because the degree of competition between imports

and the domestic like product has been limited by the degree of substitution, which is less than infinite.

Although the Armington model has been widely adopted, few empirical studies estimated Armington elasticities. Ojeda et al. (1996) pointed out that some of those few empirical studies estimated the elasticities of substitution for the U.S. industries at a various levels of aggregation that range from 0.2 to about 2 and even the high values of the elasticities are far from infinite. However, most of trade modeling analysis have not undertaken econometric estimation of the elasticities but instead relied on the estimates of those in the few literature and sensitivity analysis (Reinert and Roland-Holst, 1992).

Economic Analyses of the Effects of Dumping Using COMPAS

The previous section described in detail the Armington specification with the assumptions on demand on which is the fundamental structure of COMPAS. The elasticity of substitution was derived and it was proved that the elasticity of substitution plays an important role in the application of the Armington model. This section presents how COMPAS performs economic analyses of the effects of dumping.

Assessing the Effects of Dumping[6]

The effects of dumping on the U.S. industry producing the domestic like product are assessed by comparing the condition comparing the condition of the U.S. industry in the hypothetical absence of dumping to its condition when dumping occurs (Boltuck, 1991). The dumping margin calculated by the U.S. Department of Commerce (DOC) measures the difference between the exporter's home market price (i.e., normal or fair

[6] This study focuses on price dumping, that is, dumping found on the basis of margins calculated by comparing the price in one market (usually the exporter's home market) and the export price to the United States. Cost dumping is not considered (Boltuck, 1991).

value) and the U.S. price of the dumped product. However, it does not measure the effect of dumping.

Dumping requires that the exporter's home market is separable from the U.S. export market so that price arbitrage cannot equalize the prices in the two markets (Boltuck, 1988). In other words, there should exist some barrier for the exporter to resell its product – that has bought at the lower price in export markets – at the higher home market price. Dumping occurs for a variety of reasons: (1) International price discrimination, (2) promotional pricing, (3) predatory pricing, and (4) hidden export subsidies. International price discrimination occurs when the demand facing the exporter is more inelastic in its home market than in the U.S. export market. As a result, an exporting firm can enjoy more market power at home than in the United States and earn greater profits. International price discrimination may be persistent.

Promotional pricing occurs when an exporter first introduces a product in the market. The exporter that has confidence in the quality of its products invests for future sales by charging new customers a lower price. Because of brand loyalty, the exporter expects to be able to increase its price later without losing customers. Promotional pricing may be temporary. Predatory pricing drives competitors out of the market by lowering the export price below the marginal cost of production. The exporter expects that once the competitors leave the market, it will earn more profits by raising the price. Predatory pricing is believed to rarely arise. Hidden export subsidies is a method to avoid exposure to duties under the countervailing duty law. Hidden export subsidies generally result in dumping by causing the export price to be lower than the unsubsidized home market price.

Assuming the U.S. domestic like product is a substitute for the dumped import, the reduction in the import price causes demand for the U.S. domestic product to decrease. The stronger is the responsiveness of demand for the domestic product with respect to the import price, the greater will be the reduction of demand of the domestic product. The decrease in demand results in reducing the price of the U.S. product. The reduction in the price of the domestic product adversely affects the U.S. industry by a change in U.S. shipments or changes in demand for inputs such as capital and labor.

To start to assess the effect of dumping on the U.S. industry, a counterfactual situation is defined in which the exporter's home market and U.S. export market had integrated and the exporter would have charged a single price in both markets. In addition, the domestic like product and the dumped import are assumed to be imperfect substitutes, which is the more common case than perfect substitutable cases. Substitutable relationship means that a lower price of the dumped import induces less demand for the domestic product.

When dumping is possible. First, considering a case when dumping is possible in the U.S. market, a dumping exporter's profit, π, is as follows:

$$\pi = \left(p_H * D_H + p_M * M\right) - \left[C * \left(D_H + M\right)\right] \tag{4-34}$$

where p_H is the exporter's home market price, p_M is the price charged by the exporter in the U.S. export market (i.e., the price of the import), D_H is demand for the product in the home market, M is demand for the dumped imports in the U.S. market, and C is the average cost of production. In the home market, demand depends only on the price of the product:

$$D_H = D_H\left(p_H\right) \tag{4-35}$$

In the U.S. market, demand for the dumped import depends both on the import price and price of the domestic like product, p_D.

$$M = M(p_M, p_D) \tag{4-36}$$

The exporter's profit maximizing first-order conditions are

$$\text{(a)}\ \frac{\partial \pi}{\partial p_H} = D_H + p_H\left(\frac{\partial D_H}{\partial p_H}\right) - C\left(\frac{\partial D_H}{\partial p_H}\right) = 0$$

$$\text{(b)}\ \frac{\partial \pi}{\partial p_M} = M + p_M\left(\frac{\partial M}{\partial p_M}\right) - C\left(\frac{\partial M}{\partial p_M}\right) = 0 \tag{4-37}$$ [7]

Rewriting Equations (4-37),

$$\text{(a}'\text{)}\ p_H = \frac{C}{(1 + 1/\eta_H)}$$

$$\text{(b}'\text{)}\ p_M = \frac{C}{(1 + 1/\mu_M)} \tag{4-38}$$

where η_H is the own-price elasticity of demand in the home market and μ_M is defined as

$$\mu_M = \varepsilon_M + \varepsilon_{MD}\left(\frac{d \ln p_D}{d \ln p_M}\right) \tag{4-39}$$

In Equations (4-38), η_H and μ_M should be less than -1 since the prices, p_H and p_M, cannot be negative. $(d \ln p_D / d \ln p_M)$ in Equation (4-39) measures the percentage change in p_D generated by a percent increase in p_M. This factor can be analyzed by multiplying both sides of Equation (4-27) by (p_M / p_D) and expressed as

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[7] $\frac{\partial M}{\partial p_M} = \frac{\partial M}{\partial p_M} + \frac{\partial M}{\partial p_D}\frac{dp_D}{dp_M} = \varepsilon_M\left(\frac{M}{p_M}\right) + \varepsilon_{MD}\left(\frac{dp_D}{dp_M}\frac{M}{p_D}\right)$, where ε_M is the own-price elasticity of the import demand in the United States and ε_{MD} is the cross-price elasticity of the U.S. import demand with respect to the price of the domestic like product.

$$\frac{d\ln p_D}{d\ln p_M} = \frac{dp_D}{dp_M}\cdot\frac{p_M}{p_D} = \frac{\partial D/\partial p_M}{\partial S/\partial p_D - \partial D/\partial p_D}\cdot\frac{p_M}{p_D}$$
$$= \frac{\varepsilon_{DM}}{\varphi_D - \varepsilon_D} \tag{4-40}$$

where ε_D is the elasticity of demand for the U.S. domestic like product. ε_{DM} and φ_D are the same as defined before. Substituting Equation (4-40) into Equation (4-39),

$$\mu_M = \varepsilon_M + \frac{\varepsilon_{MD}\varepsilon_{DM}}{\varphi_D - \varepsilon_D} \tag{4-41}$$

Rewriting Equation (4-38)(b′),

$$p_M = \frac{C}{1 + \dfrac{1}{\varepsilon_M + \varepsilon_{MD}\varepsilon_{DM}/(\varphi_D - \varepsilon_D)}} \tag{4-42}$$

The exporter charges p_M in the U.S. market when dumping is possible.

When dumping is not possible. The price that the exporter charges is the same in both home and U.S. markets since the markets are integrated now. The exporter's new profit function, π_{ND}, is

$$\pi_{ND} = p_I * D_I - (C * D_I) \tag{4-43}$$

where p_I and D_I are the integrated price and demand, respectively. D_I is the sum of D_H and M:

$$D_I = D_H(p_I) + M(p_I, p_D) \tag{4-44}$$

From the profit maximizing first-order condition,

$$p_I = \frac{C}{1 + 1/\mu_I} \tag{4-45}$$

where μ_I can be expressed as the weighted average of η_H and μ_M:

$$\mu_I = a\eta_H + (1-a)\mu_M \qquad \text{where } a = \frac{D_H}{D_I} \tag{4-46}$$

μ_I is the elasticity of demand in the integrated market. Rewriting Equation (4-45),

$$p_I = \frac{C}{1 + \dfrac{1}{a\eta_H + (1-a)[\varepsilon_M + \varepsilon_{MD}\varepsilon_{DM}/(\varphi_D - \varepsilon_D)]}} \tag{4-47}$$

Since p_H is greater than p_I by the reason of dumping, η_H is also greater than μ_M. From Equation (4-46), the following is true:

$$\begin{aligned} p_M &< p_I < p_H \\ \mu_M &< \mu_I < \eta_H \end{aligned} \tag{4-48}$$

When dumping is not possible, the exporter charges the integrated price, p_I in the United States, which is higher than p_M that is the import price when dumping occurs.

Effects of dumping on the U.S. domestic industry: First, the effect of dumping on the import price is

$$d\ln p_M = \frac{dp_M}{p_M} = \frac{p_M - p_I}{p_I} \tag{4-49}$$

Since $p_M < p_I$, Equation (4-49) is negative implying that dumping causes the import price to decrease.

The effect of dumping on the price of the U.S. domestic like product is expressed as

$$d\ln p_D = \left(\frac{d\ln p_D}{d\ln p_M}\right) d\ln p_M = \frac{\varepsilon_{DM}}{\varphi_D - \varepsilon_D}\left[\frac{p_M - p_I}{p_I}\right] \tag{4-50}$$

The effect of dumping on the volume of sales of the domestic industry (or supply of the domestic products) can be analyzed as follows:

$$d \ln S = d \ln p_D \cdot \varphi_D = \frac{\varepsilon_{DM} \varphi_D}{\varphi_D - \varepsilon_D} \left[\frac{p_M - p_I}{p_I} \right] \tag{4-51}$$

In order to evaluate these effects, parameters are required to be estimated from a certain import demand model or chosen from the relevant literature. Those parameters are the proportion of the exporter's sale in its home market out of the total combined sales in both the home and U.S. markets, a; the elasticities of supply and demand of the domestic like product, φ_D and ε_D; the elasticity of demand of the product in the exporter's home market, η_H; the elasticity of demand for the imports in the U.S. market, ε_M; and the cross-price elasticities, ε_{DM} and ε_{MD}.

Interpretation of the COMPAS Spreadsheets

There are two types of data inputs required to run the COMPAS model. The first is information from the Preliminary Staff Report. The second are the estimates of the various price elasticities. All of the elasticities are not necessary to estimate. Once some of basic elasticities and market variables are provided for inputs, then the other parameters are calculated in the spreadsheets to conduct an economic analysis of unfair trade. Table 4-1 summarizes input parameters and parameters calculated in COMPAS.

Once parameters, σ, φ_D, φ_S, ε_Q, w_D, and w_M are entered into COMPAS, ε_D, ε_M, ε_{DM}, and ε_{MD} are automatically calculated in the COMPAS spreadsheets. For example, the cross-price elasticity of demand for the domestic like product with respect to a change in the price of the imports can be calculated as

$$\varepsilon_{DM} = (\sigma - \varepsilon_Q) w_M \qquad \varepsilon_{MD} = (\sigma - \varepsilon_Q) w_D \tag{4-52}$$

It is the same calculation method as derived from Equations (4-24) through (4-33). In addition, from Equations (4-33) and (4-40), the following is true:

$$-\varepsilon_D = \varepsilon_Q + \varepsilon_{DM} \tag{4-53}$$

Substituting Equation (4-52) into Equation (4-53),

$$\begin{aligned}\varepsilon_D &= -\varepsilon_Q - (\sigma - \varepsilon_Q) w_M \\ &= \varepsilon_Q w_D - \sigma w_M \text{ [8]}\end{aligned} \tag{4-54}$$

COMPAS uses the formula in Equation (4-54) to get the elasticity of demand.

Average U.S. tariff rate in Table 4-1 represents the tariff rate applied to the subject imports. Depending on the subject good, it is the actual tariff rate applicable, or in cases where several tariff lines are required, it is estimated by actual tariff revenues collected divided by import values (i.e., average tariff). The tariff rate is one of the factors needed to adjust the margin of dumping from an f.o.b. to a c.i.f. basis. The other factor is transportation ratio, which represents the cost incurred during the transportation of the subject imports between the factory and U.S. port of entry. These parameters are used to consider whether the U.S. DOC's reported dumping margin is based on ex-factory import prices which exclude any U.S. import duties, movement expenses incurred in bringing the product into the United States, commissions, selling expenses incurred on behalf of the buyer, or further manufacturing expenses. Domestic content indicates that the proportion of the value of the product that is value added to the subject imports after entering the United States. Domestic capacity utilization does not enter the basic analytic calculations of COMPAS. However, once the estimate of the impact of dumping on domestic output is calculated, COMPAS then uses this input data on domestic to estimate the change in domestic capacity utilization resulting from dumping (Featherstone, 1995).

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[8] Also, $\varepsilon_M = \varepsilon_Q w_M - \sigma w_D$.

Given elasticities and other relevant market variables, COMPAS estimates the impact of unfair trade on the U.S. market and imports. Based on the mathematical derivation of parameters required for COMPAS in the previous section, the COMPAS spreadsheets can be easily viewed and interpreted. Table 4-2 summarizes the main analysis of COMPAS. The COMPAS spreadsheets calculate the effects of dumping or subsidies using the same mathematical algorithm as previously derived in hand. COMPAS also analyzes changes in domestic capacity utilization and value shares of domestic product and imports after unfair trade occurs.

Summary

COMPAS is an analytical tool designed to assist in understanding the effect of unfair trade on the condition of the U.S. industry producing the domestic like product. The U.S. ITC uses COMPAS to support their arguments and determinations. The derivation procedures for elasticities using input parameters are built into the COMPAS template. The results depend on the quality of those parameters provided by the user. A word of warning by the COMPAS modelers is that the analysis is static and therefore, it is presumed that dynamics, lags, changes in technology, and possible gaming between firms do not alter the results (Miller and Burrows, 1991).

Table 4-1. Parameters input and calculated for COMPAS

Input parameters		Parameters calculated in COMPAS	
Elasticity of substitution:		Elasticity of demand for domestic.	ε_D
Domestic product vs. imports	σ	Elasticity of demand for imports	ε_M
Elasticity of supply of domestic.	φ_D	Cross-price elasticity:	
Elasticity of supply of imports	φ_S	Domestic vs. import price	ε_{DM}
Elasticity of aggregate demand	ε_Q	Import vs. domestic price	ε_{MD}
Value shares of domestic.	w_D		
Value shares of imports	w_M		
Margin (dumping or subsidy)			
Average U.S. tariff rate			
Transportation ratio			
Domestic content			
Domestic capacity utilization			

Table 4-2. Output in COMPAS: Estimated economic impacts

Estimated impacts on			
Domestic market		Imports	
Price	$d \ln p_D$	Price	$d \ln p_M$
Output	$d \ln S$	Output	$d \ln S_M$
Revenue	$d \ln p_D + d \ln S$	Revenue from U.S. sales	$d \ln p_M + d \ln S_M$

Microsoft Excel - COMPAS

File Edit View Insert Format Tools Data Window Help

O1 =

COMPAS Version 1.5 – COST DUMPING

by Joseph Francois and Keith Hall

INPUTS (in percentages)	8/27/2003 CNTRY		From:	To:
Margin:	20	Substitution Elast.		
Domestic Share:	55	Domsetic/Unfair:	3	5
Unfair Import Share:	35	Domestic/Fair:	3	5
Ave. Domestic Tariff Rate:	0	Unfair/Fair:	3	5
Transportation Ratio:	0	Aggregate Demand Elast:	0.5	1.5
Domestic Content:	0	Domestic Supply Elast:	5	10
Dom. Capacity Util:	80	Fair Supply Elast:	10	inf

Estimated Impact of Dumping on Domestic Market (as percent of "fair" values)									But-for
SCENARIOS	#1	#2	#3	#4	#5	#6	#7	#8	Imports:
Domestic Price:	-2.4%	-1.4%	-1.3%	-0.8%	-3.9%	-2.3%	-2.8%	-1.7%	-6.9%
Domestic Output:	-11.6%	-12.8%	-6.5%	-7.6%	-18.0%	-20.5%	-13.3%	-15.7%	-30.2%
Domestic Revenue:	-13.7%	-14.0%	-7.8%	-8.3%	-21.2%	-22.3%	-15.7%	-17.1%	-35.0%
"BUT-FOR" ESTIMATIONS									
Domestic Share:	60.6%	60.9%	61.1%	61.2%	64.5%	65.1%	65.2%	65.6%	84.6%
Unfair Import Share:	28.1%	27.7%	27.7%	27.5%	23.2%	21.9%	22.4%	21.6%	--
Fair Share:	11.2%	11.4%	11.2%	11.3%	12.4%	13.0%	12.3%	12.8%	15.4%
Capacity Utilization:	90.5%	91.8%	85.6%	86.5%	97.6%	100.6%	92.2%	94.9%	114.6%

Estimated Impact of Dumping on Imports (as a percentage of "fair" values)									
Unfair Import Price:	-16.7%	-16.7%	-16.7%	-16.7%	-16.7%	-16.7%	-16.7%	-16.7%	--
Unfair Import Output:	41.9%	44.6%	55.1%	56.0%	67.2%	76.4%	87.2%	92.6%	--
Unfair Import Revenue:	18.2%	20.5%	29.2%	30.0%	39.4%	47.0%	56.0%	60.5%	--
Fair Import Price:	-1.5%	0.0%	-0.8%	0.0%	-2.6%	0.0%	-1.9%	0.0%	-3.8%
Fair Import Output:	-14.1%	-16.3%	-8.0%	-9.7%	-23.3%	-29.1%	-17.3%	-22.6%	-32.4%
Fair Import Revenue:	-15.4%	-16.3%	-8.7%	-9.7%	-25.3%	-29.1%	-18.8%	-22.6%	-35.0%

Ready NUM

Start COMPAS 3:04 PM

Figure 4-1. COMPAS dumping spreadsheet

CHAPTER 5
ALTERNATIVE IMPORT DEMAND MODELS

Chapter 4 presented the Armington model and derived elasticities required for a trade policy analysis using COMPAS. The flexible specification of the approach is the reason why the Armington model has been used to analyze trade in many international agricultural products. In this chapter, alternative import demand models and their underlying assumptions are introduced: Rotterdam model and Almost Ideal Demand System (AIDS). Prior to these parametric analyses of demand, nonparametric demand approach is also considered in order to check for consistency of data with the theory of revealed preference.

Nonparametric Demand Analysis

The nonparametric approach to demand analysis uses the results of revealed preference analysis to test demand data for consistency with maximization, homotheticity and separability without making any assumptions concerning the parametric form of demand or utility function (Varian, 1982 and 1983). That is, the nonparametric approach deals with the raw demand data itself using mathematic techniques. The nonparametric analysis can be useful as a complement to traditional parametric demand analysis (Chavas and Cox, 1997).

Generalized Axiom of Revealed Preference (GARP)

Definition 1: Let p^i be a list of prices and x^i the associated chosen consumption bundles for $i = 1,2,\ldots,n$. A utility function rationalizes the observed behavior $\left(p^i, x^i\right)$ for $i = 1,2,\ldots,n$, if $u\left(x^i\right) \geq u\left(x\right)$ for all x such that $p^i x^i \geq p^i x$. That is,

$u(x)$ rationalizes the observed behavior if it achieves its maximum value on the budget set at the chosen bundles.

Definition 2: An observation x^i is <u>directly revealed preferred</u>(R^D) to x^j, if x^i is purchased when x^j was affordable,[1] written $x^i R^D x^j$, if $p^i x^i \geq p^i x^j$. An observation x^i is <u>revealed preferred</u>(R) to a bundle x, written $x^i R x$, if there is some sequence of bundles $(x^j, x^k, \ldots, x^l)$ such that $x^i R^D x^j$, $x^j R^D x^k$,…, $x^k R^D x^l$, $x^l R^D x$. R is called the transitive closure of the relation R^D.

Definition 3: The data satisfies Generalized Axiom of Revealed Preference (GARP) if $x^i R x^j$ implies $p^j x^i \geq p^j x^j$. GARP is equivalent to the following conditions: (a) There exists positive numbers (u^i, λ^i) for $i = 1,2,\ldots,n$ that satisfy the Afriat inequalities such as $u^j \leq u^i + \lambda^i p^i (x^j - x^i)$ for $i = 1,2,\ldots,n$, where u^i is utility level; (b) there exists a concave, monotonic, continuous, and non-satiated utility function that rationalizes the data. Thus, GARP is a necessary and sufficient condition for utility maximizing. Tests of the utility maximizing hypothesis can be constructed by considering whether there exists a solution to the Afriat inequalities (Hallam, 1992).

Homothetic Axiom of Revealed Preference (HARP)

A function is *homothetic* if it is a positive monotonic transformation of a function that is homogeneous of degree 1 – if $f(x) \equiv g(h(x))$ where $h(x)$ is homogeneous degree 1 and $g(h)$ is positive monotonic. Assuming an observed behavior compatible with the utility maximization conditions, which are the following Afriat inequalities:

---

[1] In other words, x^j cannot be chosen when x^i is affordable.

$$u^j \leq u^i + \lambda^i p^i \left(x^j - x^i\right) \tag{5-1}$$

where λ^i denotes the marginal utility of income at consumption x^i. Additionally, for convenience, prices are normalized by the level of expenditure at each observation so that $E^i = p^i x^i = 1$ for $i = 1,2,\ldots,n$. Since the following is true:

$$u\left(x^i\left(p^i, E\right)\right) = u\left(x^i\left(p^i\right)E\right) = Eu^i \text{ [2]} \tag{5-2}$$

λ^i can be expressed as follows:

$$\lambda^i = \frac{\partial u\left(x^i\left(p^i, E\right)\right)}{dE} = u^i \tag{5-3}$$

Rewriting Equation (5-1),

$$u^j \leq u^i + u^i p^i \left(x^j - x^i\right) \tag{5-4}$$

Recalling $p^i x^i = 1$, Equation (5-4) can be rewritten as

$$u^j \leq u^i p^i x^j \tag{5-5}$$

Homothetic Axiom of Revealed Preference (HARP) means that for all distinct choices of indices $(i, j, k, \ldots, m)$ we have $\left(p^i x^j\right)\left(p^j x^k\right)\cdots\left(p^m x^i\right) \geq 1$. HARP implies that there exists numbers $u^j > 0$, $i = 1,2,\ldots,n$ satisfying Equation (5-5).

Proof: Defining u^i as a minimum of the following expression,

$$u^i = \min_{(j,k,\ldots,m,i)} \left\{\left(p^j x^k\right)\left(p^k x^l\right)\cdots\left(p^m x^i\right)\right\} \tag{5-6}$$

Likewise, define u^j as

$$u^j = \left(p^n x^o\right)\left(p^o x^q\right)\cdots\left(p^r x^j\right) \tag{5-7}$$

---

[2] If the utility function is homogeneous of degree 1, then the expenditure function can be written as $e(p,u) = e(p)u$. In turn, the indirect utility function can be written as $v(p,E) = v(p)E$. By Roy's identity, the demand functions take the form $x_i(p,E) = x_i(p)E$.

Then, since u^i is a minimum over all paths to i, the following inequality is true:

$$u^i = \left(p^j x^k\right)\left(p^k x^l\right)\cdots\left(p^m x^i\right) \le \left(p^n x^o\right)\left(p^o x^q\right)\cdots\left(p^r x^j\right)\left(p^j x^i\right)$$

$$= u^j p^j x^i \tag{5-8}$$

That is, satisfaction of HARP implies the existence of a homothetic utility function that rationalizes the data. Testing HARP or homotheticity in practice can be done as follows:

$$\log\left(p^i x^j\right) + \log\left(p^j x^k\right) + \cdots + \log\left(p^m x^i\right) \ge 0 \tag{5-9}$$

Testing for Weak Separability and Homothetic Separability

Suppose the following preference ordering:

$$(x, y) \succ (x', y) \quad \text{if and only if} \quad (x, y') \succ (x', y') \tag{5-10}$$

for all consumption bundles x, x', z, and z'. This condition implies that if x is preferred x' for some choices of the other goods, then x is preferred x' for all choices of the other goods. Or, the preferences over the x- goods are *independent* of the z-goods. If the independence property is satisfied and the preferences are locally nonsatiated, the utility function for x and z can be written as in the following form:

$$u(x, y) = U(v(x), z) \tag{5-11}$$

where $U(v, z)$ is an increasing function of v. The overall utility from x and z, $u(x, y)$, can be written as a function of the subutility of x, $v(x)$, and the level of consumption of the z-goods. In this case, the utility function is known to be weakly separable.

If the data is generated by a separable utility function then the two sets of price and quantity data $\left(\left(p^i, x^i\right), \left(q^i, y^i\right)\right)$ and the data $\left(q^i, y^i\right)$ for $i = 1, 2, \ldots, n$ must both satisfy GARP. This is a necessary condition for weak separability of a subgroup. The sufficient conditions require that the data satisfy both GARP and the Afriat inequalities. The Afriat

inequalities imply that there exist numbers u^i , v^i , $\lambda^i > 0$, and $\mu^i > 0$ for $i = 1,2,\ldots,n$ that satisfy

$$u^i \le u^j + \lambda^j p^j \left(x^i - x^j\right) + \left(\frac{\lambda^j}{\mu^j}\right)\left(v^i - v^j\right)$$
$$v^i \le v^j + \mu^j q^j \left(y^i - y^j\right) \tag{5-12}$$

where $u(x,y) \equiv u(x,v(y))$ and v is a subutility function. μ^j is the marginal utility of income at consumption y^j.

For data that satisfy separability, homothetic separability can be tested. A utility function is homothetically separable if its takes the form $u(x,v(y))$, where $v(y)$ is homothetic. This case allows one to analyze the data in a two-stage budgeting process. If the data satisfy GARP for some choice v^i that satisfies the homotheticity inequalities in Equation (5-12), then there exists numbers u^i, v^i, and $\lambda^i > 0$ for $i = 1,2,\ldots,n$ such that

$$u^i \le u^j + \lambda^j p^j \left(x^i - x^j\right) + \left(\frac{\lambda^j}{v^j}\right)\left(v^i - v^j\right)$$
$$v^i \le v^j q^j y^i \tag{5-13}$$

Review of Literature

Barnhart and Whitney (1988) applied nonparametric analysis in their parametric estimation of the consumption and monetary assets. The authors examined whether the use of nonparametric analysis can provide information that improves the performance of the translog demand systems – the performance of a flexible functional form, when applied to data sets identified by nonparametric analysis as being consistent with the hypothesis of utility maximization. For the compatibility of the data with utility maximization, the observations that were found by nonparametric analysis as the source of violating the hypothesis were deleted in estimation of the translog demand systems.

Also, nonparametric analysis was used to narrow the scope of study by identifying groups of goods that are weakly separable. The authors concluded that their (indirect) translog functions perform better when applied to the data sets found consistent with utility maximization.

Alston et al. (1990) performed nonparametric methods to test whether the data from the international cotton and wheat markets are consistent with well-behaved import demand equations and separability and homotheticity assumptions hold. The testing procedures were as follows: (1) Each data set was tested with GARP; (2) for data that satisfy GARP, HARP was applied to test for homotheticity; and (3) the separability assumption was tested. The authors indicated that the principal drawback of nonparametric analysis is the unknown power of the tests and the possibility of false rejections due to measurement error. Alston and Chalfant (1992) also reviewed the nonparametric approach to consumer-demand analysis with particular attention on questions of size and power of tests for consistency of data with the existence of well-behaved utility function.

Chavas and Cox (1997) applied nonparametric techniques to empirical demand and welfare analysis in estimation of price and income elasticities. Inner-bound and outer-bound representations of preferences were obtained in order to predict consumer behavior and conduct sensitivity analysis of demand to changes in prices and income. The results showed that the U.S. consumption data for eight commodities are consistent with consumer theory and the estimated price and income elasticities are reasonable. The authors suggested keeping in mind that nonparametric approach is not statistically based, and therefore, it lacks the ability to conduct statistical testing.

Fleissig et al. (2000) examined whether annual, quarterly, and monthly U.S. aggregate consumption data have been generated by a utility maximizing representative agent. The authors found that the monthly data exhibit the high number of violations of GARP, while the quarterly and annual data are mostly consistent with GARP except a break in behavior around 1981 when the utility function may have changed. If the parameters or the functional form of the utility function change appropriately at the breakpoints, the data would be consistent with the utility maximizing hypothesis.

Parametric Demand Analysis

Rotterdam Model[3]

Using the differential approach that requires no algebraic specification of a utility function (Theil, 1980), a Rotterdam model for systems of consumer demand equations can be specified as follows:

$$w_i d\log q_i = \theta_i d\log Q + \sum_j \pi_{ij} d\log p_j \tag{5-14}$$

where $i = 1,2,\ldots,n$ and $i \in N_S$. w_i is the budget share of a good i. p_i and q_i are the price and quantity of the good i, respectively. $d\log Q$ is the Divisia volume index specified as follows:

$$d\log Q = \sum_i w_i d\log q_i \tag{5-15}$$

where w_i is the budget share of the good i (i.e., $w_i = p_i q_i / E$). The Divisia volume index is the weighted average of logarithmic quantity changes with weights of the

[3] Rotterdam model considered in this study is a conditional demand system that is valid under the condition of blockwise dependence (Theil, 1980; Theil et al., 1989). In other words, all variables in Equation (5-14) are confined to N_S that is one of total commodity groups. Therefore, the expenditure, E, is allocated for the group N_S from income for total commodities.

corresponding budget shares, representing the proportional change in real total expenditure. The coefficient of the Divisia volume index, θ_i, means the marginal share of the i th good,[4] that is, the additional amount spent on the good when income increases by one dollar. The second term of the right hand side of Equation (5-14) is the substitution factor that explains the substitution effect of n price changes on the demand for the good i.

Restrictions on demand: There is a general assumption of properties of demand functions: (1) Adding up, (2) homogeneity, and (3) symmetry (Deaton and Muellbauer, 1980b). Adding-up condition means that the total value of demands is total expenditure. Homogeneity implies that demands are homogeneous of degree zero in total expenditure and prices. Finally, symmetry assumption tells that the cross-price derivatives of demands are symmetric. A general functional form can be estimated with and without there three restrictions testing whether the restrictions may be imposed or not.

The parameters of the Rotterdam model can be related to the theoretical demand restrictions. Adding up requires that the marginal propensities to spend on each good sum to unity and that the net effect of a price change on the budget be zero:

$$\sum_i \theta_i = 1 \qquad \sum_i \pi_{ij} = 0 \tag{5-16}$$

Homogeneity and symmetry can be imposed such that

$$\sum_j \pi_{ij} = 0$$
$$\pi_{ij} = \pi_{ji} \qquad \text{for all } i \text{ and } j \tag{5-17}$$

[4] θ_i is defined as conditional marginal share since the Rotterdam model in Equation (5-14) is conditional.

Almost Ideal Demand System (AIDS)

Deaton and Muellbauer (1980a) proposed a demand model derived from the cost or expenditure function which defines the minimum expenditure necessary to attain a specific utility level at given prices (i.e., *PIGLOG* preferences).[5] The model, called Almost Ideal Demand System (AIDS), can be specified in budget share form as follows:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left(\frac{E}{P}\right) \tag{5-18}$$

where $i = 1,2,\ldots,n$. w_i is the budget share and E is the total expenditure. $\log P$ is a price index defined by

$$\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \frac{1}{2}\sum_j \sum_k \gamma_{kj} \log p_k \log p_j \tag{5-19}$$

The AIDS can be approximated at the estimation stage by a linear form. This linear AIDS model typically utilizes the following Stone's price index:

$$\log P^* = \sum_k w_k \log p_k \tag{5-20}$$

The model that uses Stone's price index is called the Linear Approximate AIDS (LA/AIDS) (Green and Alston, 1990). Since the LA/AIDS is not itself derived from a well-specified representation of preferences, it is of interest only as an approximation to the nonlinear AIDS (Moschini, 1995). Therefore, it is important to ensure good approximation properties for the LA/AIDS.

Restrictions on demand: Adding-up, homogeneity, and symmetry restrictions on the parameters of the AIDS require that

[5] *PIGLOG* preferences permit exact aggregation over consumers and therefore, market demands are represented as if they were the outcome of decisions by a rational representative consumer.

$$\sum_i \alpha_i = 1 \qquad \sum_i \gamma_{ij} = 0 \qquad \sum_i \beta_i = 0$$
$$\sum_j \gamma_{ij} = 0$$
$$\gamma_{ij} = \gamma_{ji} \qquad \text{for all } i \text{ and } j \tag{5-21}$$

Provided Equations (5-21) hold, an AIDS in Equation (5-18) represents a system of demand functions which add up to total expenditure, are homogeneous of degree zero in prices and total expenditure taken together, and satisfy symmetry.

In the time-series context, the AIDS is often compared with the Rotterdam model. The first difference form of the AIDS is

$$\Delta w_i = \beta_i \Delta \log\left(\frac{E}{P}\right) + \sum_j \gamma_{ij} \Delta \log p_j \tag{5-22}$$

The right-hand side of Equation (5-22) is equivalent to that of the Rotterdam model in Equation (5-14) noting that the dependent variables are different in both models. Although such a similarity exists, the fundamental difference between two models is that the AIDS is derived from an explicit characterization of preferences, however the Rotterdam model does not require any specific assumption on preferences.

More on Separability and Homotheticity

Separability of preferences implies that the commodities can be partitioned into groups so that preferences within groups can be described independently of the quantities in other groups.[6] Hence, the separability imposes restrictions on behavior that limit the possible substitution effects between goods in different groups. Two separability

[6] Separability structures are not nested in the general specification of the AIDS (Barten, 1993). The AIDS model comes from a unique cost function that is not separable. When the AIDS functional form is used in a conditional model, the AIDS is not the original Deaton and Muellbauer's model.

concepts are broadly applied to demand analysis: Strong separability and weak separability.

The utility function $u(x)$ is called *strongly separable* with respect to the partition, $\{N_1, N_2, \ldots, N_S\}$, if the marginal rate of substitution $u_i(x)/u_j(x)$ between two commodities i and j from different subsets N_s and N_t, respectively, does not depend on the quantities of commodities outside of N_s and N_t (Goldman and Uzawa, 1964):

$$\frac{\partial u_i(x)/u_j(x)}{\partial x_k} = 0 \qquad \text{for all} \quad i \in N_s,\ j \in N_t \qquad \text{and} \quad k \notin N_s \cup N_t \ (s \neq t) \tag{5-23}$$

On the other hand, the utility function $u(x)$ is called *weakly separable* with respect to a partition, $\{N_1, N_2, \ldots, N_S\}$, if the marginal rate of substitution $u_i(x)/u_j(x)$ between two commodities i and j from N_s is independent of the quantities of commodities outside of N_s:

$$\frac{\partial u_i(x)/u_j(x)}{\partial x_k} = 0 \qquad \text{for all} \quad i, j \in N_s \qquad \text{and} \quad k \notin N_s \tag{5-24}$$

Only the latter concept of separability is considered in this study and therefore, the separability means weak separability from now on.

The separability, often called, *blockwise dependence* is related to a two-stage budgeting process (Deaton and Muellbauer, 1980b).[7] If any subset of commodities

[7] This research considers a two-stage budgeting rather than multi-stage budgeting process. In the two-stage budgeting process, first, total expenditure is allocated to broad groups, then, in the second stage, expenditure on each group is allocated to domestic products and imports by sources. Shiells et. al (1993) refer to this process as the nonnested specification in comparison with the nested specification of the multi-stage budgeting process.

appears in a separable subutility function, then quantities demanded within the group can be written as a function of group expenditure and prices within the group alone. Subsequently, the separability can be characterized by using the Slutsky terms of demand functions. Let x_i be a subgroup or conditional demand for all i within a group N_s, I_s the total expenditure on N_s, and p_s the vector of prices of all goods within N_s:

$$x_i = f(I_s, p_s) \tag{5-25}$$

Differentiating Equation (5-25) with respect to the price of a good k, p_k, (where $k \in N_r$ and $N_s \neq N_r$) and holding utility (u) constant,

$$s_{ik} = \frac{\partial x_i}{\partial I_s} \cdot \frac{\partial I_s}{\partial p_k}\bigg|_{u=cons\tan t} \tag{5-26}$$

where s_{ik} is the compensated cross-price effect. The effect of a change in p_k should be through I_s. By symmetry,

$$\begin{aligned} s_{ik} &= s_{ki} \\ \frac{\partial x_i}{\partial I_s} \cdot \frac{\partial I_s}{\partial p_k}\bigg|_{u=cons\tan t} &= \frac{\partial x_k}{\partial I_r} \cdot \frac{\partial I_r}{\partial p_i}\bigg|_{u=cons\tan t} \\ \frac{\partial I_s / \partial p_k}{\partial x_k / \partial I_r}\bigg|_{u=cons\tan t} &= \frac{\partial I_r / \partial p_i}{\partial x_i / \partial I_s}\bigg|_{u=cons\tan t} \end{aligned} \tag{5-27}$$

where x_k is a subgroup or conditional demand for all k within a group N_r, I_r the total expenditure on N_r, and p_i the price of a good i in the group N_s. Multiplying both sides of Equation (5-27) by $\partial x_k / \partial I_r$,

$$\begin{aligned} \frac{\partial I_s}{\partial p_k}\bigg|_{u=cons\tan t} &= \frac{\partial I_r / \partial p_i}{\partial x_i / \partial I_s}\bigg|_{u=cons\tan t} \cdot \frac{\partial x_k}{\partial I_r} \\ \frac{\partial I_s}{\partial p_k}\bigg|_{u=cons\tan t} &= \lambda_{sr} \frac{\partial x_k}{\partial I_r} \end{aligned} \tag{5-28}$$

where the expression, λ_{sr}, is independent of k. Rewriting Equation (5-26),

$$s_{ik} = \mu_{sr} \frac{\partial x_i}{\partial I} \cdot \frac{\partial x_k}{\partial I} \qquad \text{where } \mu_{sr} \frac{\partial I_s}{\partial I} \cdot \frac{\partial I_r}{\partial I} = \lambda_{sr} \tag{5-29}$$

where I is total expenditure for all of the groups. μ_{sr} is interpreted as a measure of the substitutability between commodities in group N_s and N_r (Capps et al., 1994). The separability provides no restrictions on substitution between commodities within each group, however between groups, substitution is limited by Equation (5-29).

Preferences are homothetic if doubling quantities doubles utility. That is, a straight line from the origin will cut all the indifference curves at points where the slope is the same. The implication of homothetic preferences is that the composition of the budget is independent of total expenditure or of utility, and therefore all expenditure elasticities are unity. In the context of trade allocation model, homotheticity implies that the import shares are independent of the overall level imports.

Review of Literature

Winters (1984) showed that the traditional assumption of trade allocation models, that the demand for domestic and foreign goods is separable, is false by using a Lagrange Multiplier (LM) test, which involves estimating the equation under the null hypothesis of separability and then relaxing the restrictions of the null. The author first estimated the AIDS of U.K manufactured imports containing only import specific information and then added domestic prices in order to perform the LM test. The Armington assumptions of homotheticity and separability between all import sources were tested and rejected. The author argued that the Armington model with the highly constrained price responses should not be used. Brenton (1989) used similar approach to test separability between

imports and domestic production and between different imported commodity groups for the study of U.K. imports from the six European countries and concluded that the separability assumption is not universally applicable and therefore should be considered when analyzing separable trade flow models.

Hayes et al. (1990) developed a test for the hypothesis regarding perfect substitutability of Japanese domestic (Wagyu) beef and import-quality beef using a likelihood ratio test. The well-behaved LA/AIDS of the Japanese meat demand was used: It satisfied the theoretical restrictions of homogeneity and Slutsky symmetry. The hypothesis that Wagyu and imported beef are perfectly substitutes was set up as follows: The price and expenditure coefficients in the Wagyu and imported beef equations were restricted to be equal. The null hypothesis was rejected, implying that each type of beef must be treated as a separate commodity in analyzing the effects of Japanese beef import policies on the Japanese livestock industry.

Seale et al. (1992) used a Rotterdam import allocation model to fit data for U.S. fresh apple imports in four export markets by choosing a multistage budgeting process. Assuming block independence between domestic and imported goods that implies domestic and imported goods are separable, demand for imported goods was estimated conditional on total import expenditure but independently of demand for domestic goods. Furthermore, by blockwise dependence, the total import expenditure was allocated among all imported goods, and then, the expenditure on each good was allocated among all source countries. The authors tested the Armington assumptions of homotheticity and separability among imported apple suppliers. The tests rejected homotheticity but not separability.

Moschini et al. (1994) derived a general elasticity representation of the necessary and sufficient conditions for weak separability and homothetic weak separability of the utility function. Parametric restrictions required to implement the separability conditions were presented for the AIDS, translog, and Rotterdam models. The authors distinguished between symmetric and asymmetric separable structures. If the utility function is symmetrically separable, the Slutsky substitution term between two goods in different groups is as illustrated in Equation (5-29). However, it requires at least two goods in any one separable group. For asymmetric weak separability, the Slutsky substitution term can be expressed as follows:

$$s_{ik} = \mu_k \frac{\partial x_i}{\partial I} \cdot \frac{\partial x_k}{\partial I} \tag{5-30}$$

where μ_k is independent of i. The authors also suggested that the Rotterdam model is separability-flexible for the purpose of modeling weak separability, although it cannot be considered an exact representation of preferences.

Weatherspoon and Seale (1995) estimated Japanese import demand for beef by source using a system-wide differential approach. Two import demand allocation models – the CBS and Rotterdam models – were developed and tested to determine which model better fit the data. The CBS and Rotterdam models were nested and a likelihood ratio test indicated that the functional form of the CBS model fit the data better. A test for homotheticity was not rejected implying that Japan did not discriminate against Australian beef in the beef import market (i.e., in the absence of changes in relative prices), the trade shares would have remained unchanged. The authors suggested that the changes in trade shares over time (decrease in Australia's trade share and increase in the U.S.'s) are due to relative price changes between Australia and U.S. beef prices.

CHAPTER 6
ESTIMATION AND RESULTS

This chapter presents the estimation result of empirical demand analysis on fresh tomatoes in the United States. Price elasticities are calculated from each econometric model. Data for this study are described with the summary sample statistics. The consistency of the data with economic theory is checked using nonparametric methods. Finally, COMPAS for the U.S. fresh tomato industry is simulated under the different specifications of input parameters estimated from the econometric models.

Data

Monthly data for fresh tomatoes from 1990 to 2001 are used in this research. Price and quantity data for tomatoes are obtained from U.S. Tomato Statistics electronically published by Economic Research Service of the U.S. Department of Agriculture (ERS, 2003b). Monthly imports data during the same periods are collected from the World Trade Atlas program developed by Global Trade Information Services, Inc. in cooperation with the Bureau of the Census of the U.S. Department of Commerce.[1] Import sources of fresh tomatoes are Mexico and Canada.

Figure 6-1 shows monthly prices for U.S., Mexican, and Canadian fresh tomatoes during the period from January 1990 to December 2001.[2] All prices have changed

[1] The same data can be found at Foreign Agricultural Service (FAS) online, USDA (http://www.fas.usda.gov/ustrade/USTImFatus.asp?QI=)

[2] Grower prices are used for the U.S. fresh tomatoes. Import prices are calculated by dividing the sum of the value by the sum of the quantity.

frequently.[3] Table 6-1 summarizes correlation coefficients among three prices (USP, MXP, and CDP, respectively). The correlation coefficient of Mexican tomato prices with lag prices of U.S. domestic fresh tomatoes (USP(-1)) is 0.6718, which is higher than 0.3813 (correlation coefficient between USP and MXP). The sample statistics for domestic and imported tomato expenditure shares from 1990 to 2001 are summarized in Table 6-2. During the period, the expenditure share of the U.S. domestic fresh tomatoes averaged 65%, while Mexican and Canadian fresh tomatoes accounted for 31% and 4%, respectively.

Nonparametric test: The nonparametric approach to demand analysis uses the results of revealed preference analysis. Generalized axiom of revealed preference (GARP) was tested for the compatibility of data with theory of maximization of a utility function using MatLab 6.2.[4] Each data set of U.S., Mexican, and Canadian fresh tomatoes was tested with GARP. All three data sets satisfied GARP. That is, the number of observations that violated GARP was found to be none in each data series.

Estimation of Elasticities

There are two approaches to obtain the value of elasticities required for the COMPAS analysis (Boltuck, 1996): Econometric estimation and review of literature. Econometric estimates of the elasticities for the imports and domestic like product could be prepared provided that there are statistical data on volumes and prices for the goods

[3] Absolute comparison of those prices is not possible since the prices are the average prices of aggregated tomatoes. For example, in 2000, most imports (43%) from Canada were greenhouse tomatoes, while greenhouse tomatoes accounted for only 4% of total fresh tomato imports from Mexico.

[4] Also NONPAR program developed by Varian (1996) can be run in Mathematica 4.0. Instead, this research tested the GARP in the MatLab software. The MatLab code for the GARP is available at http://people.cornell.edu/pages/asu1/notes/revpref.html.

over the historical period. Unfortunately, the required data are seldom available for the narrowly defined products, which are involved in injury inquiries (Featherstone, 1995).

In that case, a review of the economic literature may provide econometric estimates of elasticities for goods that are similar – not the exactly same – to the subject imports and the domestic goods under the consideration. Those previous studies usually cover an earlier period that does not include the current period of investigation. The lack of an exact match between the goods in the literature and the goods in the investigation, and the difference in time periods suggest that the elasticities from the literature should not be used directly as the elasticities required for the COMPAS analysis. However, the historical estimates of elasticities are useful in setting the range for the elasticities. In such a circumstance where econometric estimates cannot be prepared, Featherstone proposed the following common set of guidelines for the various elasticities in the COMPAS model based on the literature: There are low, moderate, and high ranges with a maximum value of the elasticities which would facilitate the COMPAS analysis. Table 6-3 summarizes those ranges and maximum values.

Related Study

Almonte-Alvarez (1997) and Almonte-Alvarez and Conley (2003) estimated four different econometric models in order to obtain empirical elasticities necessary for the CADIC analysis. The CADIC – Comparative Analysis of the Domestic Industry's Condition – model was developed by the U.S. International Trade Commission (ITC) for trade policy change analysis. Similar to COMPAS, the underlying framework of CADIC is an imperfect substitute model or Armington model. The authors employed own and cross-price elasticities estimated from their econometric models into the specification of the CADIC model and compared those with the results from the U.S. ITC's own CADIC

analysis. Their four different models are simple and multiple linear regression models, point method, and double-log multiple linear regression model that is based on a modified Armington procedure. Using actual price and volume data,[5] the authors empirically proved and concluded that there was no substitutability among the less than fair value import, domestic-like product, and non-subject imports, and therefore, the CADIC outcome obtained by using behavioral estimates instead of econometric estimates of elasticities was not only invalid but also far from the actual situation.

The objective of this study is identical to Almonte-Alvarez and Conley's works in that both studies try to find a weakness of the methodology used by the U.S. ITC when assessing trade-related injury or gain caused to a domestic industry by dumping or subsidy. However, the present study approaches to the objective using demand analysis. Elasticities are calculated from three different econometric demand models and input into the COMPAS model.

Estimation of Empirical Demand Models

Estimation procedures of this study followed the assumption that domestic products are not separable from the imported good. Accordingly, a demand model includes information of both domestic and imported products. Three different demand models were estimated: double-log demand model, Rotterdam model, and Almost Ideal Demand System (AIDS). Specially, the double-log demand model was used with parameter restrictions in order to check whether the Armington assumptions are appropriate for the fresh tomato data. Theoretical demand restrictions are maintained when each demand

[5] Almonte-Alvarez and Conley used the data from the U.S. ITC Preliminary Staff Report (1996a). The monthly data in the report were provided by questionnaires issued to U.S. growers, packers, and importers containing total quantity and total value of fresh tomatoes that were shipped to unrelated U.S. customers for the period from 1993 to 1996.

model is estimated. The following sub-sections present econometric estimation results and calculation of own and cross-price elasticities.

Seemingly unrelated regression

Each demand model was estimated for the fresh tomato data using seemingly unrelated regressions (SUR) techniques, which are usually employed when the disturbance in the regression equation under consideration could be correlated with the disturbance in some other regression equations in the system. A common multiple equation structure is as follows:

$$\begin{aligned} \mathbf{y_1} &= \mathbf{X_1}\boldsymbol{\beta}_\mathbf{1} + \boldsymbol{\varepsilon}_\mathbf{1} \\ \mathbf{y_2} &= \mathbf{X_2}\boldsymbol{\beta}_\mathbf{2} + \boldsymbol{\varepsilon}_\mathbf{2} \\ &\vdots \\ \mathbf{y_M} &= \mathbf{X_M}\boldsymbol{\beta}_\mathbf{M} + \boldsymbol{\varepsilon}_\mathbf{M} \end{aligned} \tag{6-1}$$

where $\mathbf{y_m}$ (m = 1,2,…,M) is a ($T \times 1$) vector of the sample values of the dependent variable, $\mathbf{X_m}$ is a ($T \times K_m$) matrix of the sample values of the explanatory variables, $\boldsymbol{\beta}_\mathbf{m}$ is a ($K_m \times 1$) vector of the regression coefficients, and $\boldsymbol{\varepsilon}_\mathbf{m}$ is a ($T \times 1$) vector of the sample values of the disturbances. $\boldsymbol{\varepsilon}_\mathbf{m}$ is assumed to be normally distributed with the following zero mean and variance-covariance matrix:

$$\begin{aligned} &E(\boldsymbol{\varepsilon}_{\mathbf{m}t}) = 0 \qquad\qquad \text{where } t = 1,2,\ldots,T \\ &E(\boldsymbol{\varepsilon}_\mathbf{m}\boldsymbol{\varepsilon}_\mathbf{m}') = \sigma_{mm}\mathbf{I_T} \end{aligned} \tag{6-2}$$

where $\mathbf{I_T}$ is an identity matrix of order ($T \times T$). The explanatory variables are taken to be nonstochastic and such that $(\mathbf{X_m}'\mathbf{X_m})/T$ is nonsingular and its limit exists. Now, suppose the possibility that the regression disturbances in different equations are correlated, the covariance matrix of the disturbances of the m th equation and the p th equation that is assumed to be constant over all observations is as follows:

$$E\left(\boldsymbol{\varepsilon}_{\mathbf{m}}\boldsymbol{\varepsilon}_{\mathbf{p}}'\right)=\sigma_{mp}\mathbf{I}_{\mathbf{T}} \qquad \text{where } m,p=1,2,\ldots,M$$

or

$$\boldsymbol{\Omega}=V(\boldsymbol{\varepsilon})=\begin{bmatrix}\sigma_{11} & \sigma_{12} & \cdots & \sigma_{1M}\\ \sigma_{21} & \sigma_{22} & \cdots & \sigma_{2M}\\ \vdots & \vdots & & \vdots\\ \sigma_{M1} & \sigma_{M2} & \cdots & \sigma_{MM}\end{bmatrix}\otimes\mathbf{I}_{\mathbf{T}} \tag{6-3}$$

In this case, the system of M equations is called a system of *seemingly unrelated regression* equations. The estimator of the coefficient vector ($\boldsymbol{\beta}_{\mathbf{m}}$) is obtained by a generalized least squares formula:

$$\mathbf{b}^{*}=(\mathbf{X}'\boldsymbol{\Omega}^{-1}\mathbf{X})^{-1}\mathbf{X}'\boldsymbol{\Omega}^{-1}\mathbf{y}$$

or

$$\mathbf{b}^{*}=\begin{bmatrix}\mathbf{b}_{\mathbf{1}}^{*}\\ \mathbf{b}_{\mathbf{2}}^{*}\\ \vdots\\ \mathbf{b}_{\mathbf{M}}^{*}\end{bmatrix}=\begin{bmatrix}\sigma^{11}(\mathbf{X}_{\mathbf{1}}'\mathbf{X}_{\mathbf{1}}) & \sigma^{12}(\mathbf{X}_{\mathbf{1}}'\mathbf{X}_{\mathbf{2}}) & \cdots & \sigma^{1M}(\mathbf{X}_{\mathbf{1}}'\mathbf{X}_{\mathbf{M}})\\ \sigma^{21}(\mathbf{X}_{\mathbf{2}}'\mathbf{X}_{\mathbf{1}}) & \sigma^{22}(\mathbf{X}_{\mathbf{2}}'\mathbf{X}_{\mathbf{2}}) & \cdots & \sigma^{2M}(\mathbf{X}_{\mathbf{2}}'\mathbf{X}_{\mathbf{M}})\\ \vdots & \vdots & & \vdots\\ \sigma^{M1}(\mathbf{X}_{\mathbf{M}}'\mathbf{X}_{\mathbf{1}}) & \sigma^{M2}(\mathbf{X}_{\mathbf{M}}'\mathbf{X}_{\mathbf{2}}) & \cdots & \sigma^{MM}(\mathbf{X}_{\mathbf{M}}'\mathbf{X}_{\mathbf{M}})\end{bmatrix}^{-1}$$
$$\times\begin{bmatrix}\sum_{m=1}^{M}\sigma^{1m}\mathbf{X}_{\mathbf{1}}'\mathbf{y}_{\mathbf{m}}\\ \sum_{m=1}^{M}\sigma^{2m}\mathbf{X}_{\mathbf{2}}'\mathbf{y}_{\mathbf{m}}\\ \vdots\\ \sum_{m=1}^{M}\sigma^{Mm}\mathbf{X}_{\mathbf{M}}'\mathbf{y}_{\mathbf{m}}\end{bmatrix} \tag{6-4}$$

where σ^{mp} represents the element that appears in the m th row and p th column of the inverse matrix of $\boldsymbol{\Omega}$. The variance-covariance matrix of the estimator ($\mathbf{b}^{*}$) is $(\mathbf{X}'\boldsymbol{\Omega}^{-1}\mathbf{X})^{-1}$ or

$$V(\mathbf{b}^{*})=\begin{bmatrix}\sigma^{11}(\mathbf{X}_{\mathbf{1}}'\mathbf{X}_{\mathbf{1}}) & \sigma^{12}(\mathbf{X}_{\mathbf{1}}'\mathbf{X}_{\mathbf{2}}) & \cdots & \sigma^{1M}(\mathbf{X}_{\mathbf{1}}'\mathbf{X}_{\mathbf{M}})\\ \sigma^{21}(\mathbf{X}_{\mathbf{2}}'\mathbf{X}_{\mathbf{1}}) & \sigma^{22}(\mathbf{X}_{\mathbf{2}}'\mathbf{X}_{\mathbf{2}}) & \cdots & \sigma^{2M}(\mathbf{X}_{\mathbf{2}}'\mathbf{X}_{\mathbf{M}})\\ \vdots & \vdots & & \vdots\\ \sigma^{M1}(\mathbf{X}_{\mathbf{M}}'\mathbf{X}_{\mathbf{1}}) & \sigma^{M2}(\mathbf{X}_{\mathbf{M}}'\mathbf{X}_{\mathbf{2}}) & \cdots & \sigma^{MM}(\mathbf{X}_{\mathbf{M}}'\mathbf{X}_{\mathbf{M}})\end{bmatrix}^{-1} \tag{6-5}$$

The estimator in (6-4) is a best linear unbiased estimator. In addition, under the assumption that the disturbances are normally distributed; the estimator is also a maximum likelihood estimator. It is to be noted that if $\mathbf{X_1} = \mathbf{X_2} = \ldots = \mathbf{X_M}$, the estimator in (6-4) is identical with estimators provided by single-equation least squares even if the disturbance terms in different equations are correlated (Zellner, 1962).

Generally, $\mathbf{\Omega}$ is unknown. In that case, $\mathbf{\Omega}$ is replaced by a consistent estimator of $\mathbf{\Omega}$. One technique is to estimate the variances and covariances from ordinary – single-equation – least square residuals (e_{mt}). Then, a consistent estimator of $\mathbf{\Omega}$ is

$$\hat{\mathbf{\Omega}} = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1M} \\ s_{21} & s_{22} & \cdots & s_{2M} \\ \vdots & \vdots & & \vdots \\ s_{M1} & s_{M2} & \cdots & s_{MM} \end{bmatrix} \otimes \mathbf{I_T}$$

$$\text{where } s_{mp} = \frac{\sum_{t=1}^{T} e_{mt} e_{pt}}{T - K_m} \qquad m, p = 1,2,\ldots,M \tag{6-6}$$

s_{mm} is an unbiased and consistent estimator of σ_{mm} and s_{mp} is a consistent estimator of σ_{mp} ($m \neq p$). The resulting estimator of $\boldsymbol{\beta}$ is

$$\mathbf{b} = (\mathbf{X}'\hat{\mathbf{\Omega}}^{-1}\mathbf{X})^{-1}\mathbf{X}'\hat{\mathbf{\Omega}}^{-1}\mathbf{y} \tag{6-7}$$

An alternative approach to estimate the elements of $\mathbf{\Omega}$ is the maximum likelihood method (Kmenta, 1997). The log likelihood function for $\mathbf{y}$ is

$$L = -\frac{MT}{2}\log(2\pi) - \frac{1}{2}\log|\mathbf{\Omega}| - \frac{1}{2}(\mathbf{y} - \mathbf{X\beta})'\mathbf{\Omega}^{-1}(\mathbf{y} - \mathbf{X\beta}) \tag{6-8}$$

Differentiating L with respect to the elements of $\boldsymbol{\beta}$ and $\mathbf{\Omega}$, setting the resulting derivatives equal to zero, and finally solving for the values of the unknown parameters, the maximum likelihood estimators of $\boldsymbol{\beta}$ and $\mathbf{\Omega}$ are as follows:

$$\tilde{\mathbf{b}} = (\mathbf{X}'\tilde{\boldsymbol{\Omega}}^{-1}\mathbf{X})^{-1}\mathbf{X}'\tilde{\boldsymbol{\Omega}}^{-1}\mathbf{y}$$

$$\tilde{\boldsymbol{\Omega}} = \begin{bmatrix} \tilde{\sigma}_{11} & \tilde{\sigma}_{12} & \cdots & \tilde{\sigma}_{1M} \\ \tilde{\sigma}_{21} & \tilde{\sigma}_{22} & \cdots & \tilde{\sigma}_{2M} \\ \vdots & \vdots & & \vdots \\ \tilde{\sigma}_{M1} & \tilde{\sigma}_{M2} & \cdots & \tilde{\sigma}_{MM} \end{bmatrix} \otimes \mathbf{I_T}$$

$$\text{where} \quad \tilde{\sigma}_{mp} = \frac{1}{T}(\mathbf{y_m} - \mathbf{X_m}\tilde{\boldsymbol{\beta}}_\mathbf{m})'(\mathbf{y_p} - \mathbf{X_p}\tilde{\boldsymbol{\beta}}_\mathbf{p})$$

$$m, p = 1,2,\ldots,M \text{ [6]} \tag{6-9}$$

In the following sections, each of the demand models is briefly described and estimation results using the SUR techniques are presented.[7]

Double-log demand model

Starting with the following logarithmic demand function,

$$\log q_i = \alpha_i + \sum_j r_{ij} \log p_j + b_i \log E \tag{6-10}$$

where q_i is the quantity from source i, p_j is the price of products from source j, and E is total expenditure. For the purpose of empirical estimation of elasticities, this model has been frequently applied since parameters of the model themselves present elasticity. The total expenditure elasticities (e_i) and uncompensated price elasticities (e_{ij}) are as the following:

$$e_i = \frac{\partial \log g_i}{\partial \log E} = b_i$$

$$e_{ij} = \frac{\partial \log g_i}{\partial \log p_j} = r_{ij} \tag{6-11}$$

That is, Equation (6-10) can be rewritten as

[6] The command in the TSP program for the first technique is "SUR", while for the latter maximum likelihood technique "LSQ" command is appropriate. Under the assumption of the normality of disturbances, this study applied "LSQ" command for the estimation.

[7] The econometric package used in this study is TSP Version 4.4.

$$\log q_i = \alpha_i + \sum_j e_{ij} \log p_j + e_i \log E \tag{6-12}$$

From the Slutsky equation, the following relationship is true:

$$e_{ij} = e_{ij}^* - e_i w_j \tag{6-13}$$

where e_{ij}^* is the compensated cross-price elasticity and w_j is the budget share.[8] Substituting Equation (6-13) into Equation (6-12),

$$\log q_i = \alpha_i + \sum_j e_{ij}^* \log p_j + e_i \left(\log E - \sum_j w_j \log p_j \right) \tag{6-14}$$

Let $\sum_j w_j \log p_j$ be $\log P^*$ as a price index, then the demand model in Equation (6-10) can be expressed in terms of real expenditure and compensated prices:

$$\log q_i = \alpha_i + \sum_j e_{ij}^* \log p_j + e_i \log\left(\frac{E}{P^*} \right) \tag{6-15}$$

Homogeneity of Equation (6-12) implies the following:

$$\sum_j e_{ij}^* = 0 \tag{6-16}$$

The corresponding elasticities of the model in Equation (6-15) are

Total expenditure elasticities:	$\eta_i = e_i$	(6-17)
Uncompensated cross-price elasticities:	$\varepsilon_{ij} = e_{ij}^* - e_i w_j$	(6-18)
Compensated cross-price elasticities:	$\varepsilon_{ij}^* = e_{ij}^*$	(6-19)

Now, theoretical demand restrictions are considered particularly for this model. The model itself in Equation (6-15) is homogeneous of degree zero in all prices and total expenditure (i.e., no need to test homogeneity). In general, the adding-up and symmetry

[8] Detailed derivation of elasticities and theoretical demand restrictions for each demand model are presented in Appendix.

restrictions are not possible to impose into a double-log specification.[9] However, related to the adding-up and symmetry restrictions, the original Armington model is nested within the double-log specification in Equation (6-15) under the following conditions:[10]

Demands are homothetic:	$e_i = 1 \quad \forall\ i$	
Weak separability –		
Only the own-price is included:	$e_{ij}^{\ *} = 0 \quad \forall\ i \neq j$	
Single CES:	$e_{ii}^{\ *} = e_{jj}^{\ *} = -\sigma \quad \forall \quad i, j$	(6-20)

where σ is the elasticity of substitution for the system.

The parameter restrictions in (6-20) were tested to check whether the Armington assumptions are valid for the fresh tomato data using the likelihood ratio (LR) procedures. The LR test is based on the idea that if the restrictions are true, the value of the likelihood function maximized with the restrictions imposed cannot differ too much from the value of the likelihood function maximized without the imposition of the restrictions. Asymptotically, the LR test obtains the following test statistics:

$$\lambda = 2(L_{UR} - L_R) \sim \chi^2{}_{(m)} \tag{6-21}$$

where L_{UR} and L_R are, respectively, the maximum value of the unrestricted log-likelihood function and the maximum value of the restricted log-likelihood function. The test statistics λ follows the chi-square (χ^2) distribution with the degree of freedom (m) equal to the number of restrictions, which can be determined by subtracting the number of the restricted coefficient from the number of the unrestricted coefficient.

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[9] The reasons that the adding-up and symmetry restrictions cannot be imposed are described in Appendix.

[10] Recall that the original Armington model is specified as follows: $w_i = b_i^{\sigma}\left(\frac{p_i}{P}\right)^{1-\sigma}$, where P is the price index.

The result of the LR tests is summarized in Table 6-4. The Armington restrictions were comprehensively rejected with the chi-square tests. The full Armington restriction was also rejected.[11] When the full Armington restrictions were imposed into the double-log demand model, elasticity of substitution could be estimated. In its preliminary antidumping investigation, the U.S. ITC believed that there exists moderate degree of substitution between the domestic tomatoes and Mexican imports. From Table 6-3, the range of moderate degree of substitution is 1 to 3, and the empirical estimate of elasticity of substitution in this research is 1.1076, which is near the lower bound of that range set by the U.S. ITC.

Table 6-5 presents the SUR estimates of the double-log demand model for fresh tomatoes using monthly data from 1990 to 2001. Equations estimated were demand for U.S. (US), Mexican (MX), and Canadian (CD) tomatoes. Own price exhibits a statistically significant effect in the Mexican and Canadian tomato demand equations. All six cross price parameters are statistically significant implying that the expenditure shares of all three tomatoes depend on the prices of other commodities. The expenditure variable is statistically significant in all three equations.

Uncompensated (Marshallian) and compensated (Hicksian) price and expenditure elasticities and their variances were calculated from the parameter estimates, and the results are summarized in Tables 6-6 and 6-7. Uncompensated elasticities contain both price and income effects, while compensated elasticities only include price effects. Especially, compensated price elasticities hold real income and all other prices constant,

[11] This research tested whether the Armington assumptions are rejected in a double-log functional form. The author agrees that rejection could be based on the functional form of the double-log demand model but not really based on the data itself.

and therefore it reflects pure substitution effects (Weatherspoon and Seale, 1995). In the double-log demand model in Equation (6-15), the price coefficients can be interpreted as compensated price elasticities.[12] The elasticities were calculated at the sample mean of each commodity expenditure share. The uncompensated own price elasticities of each tomato show negative signs and are statistically significant. Expenditure elasticities for all three tomatoes are positive and statistically significant at the 5% level indicating that they are normal goods. The compensated own price elasticities for all three tomatoes are also negative. Negative cross-price elasticities indicate that commodities are complements, while positive cross-price elasticities indicate a substitute relationship.

Rotterdam model

A conditional Rotterdam model can be written as follows:

$$w_i d\log q_i = \theta_i d\log Q + \sum_j \pi_{ij} d\log p_j \tag{6-22}$$

where $d\log Q$ is the Divisia volume index and defined as follows:

$$d\log Q = d\log E - \sum_k w_k d\log p_k = \sum_k w_k d\log q_k \tag{6-23}$$

The corresponding elasticities for the Rotterdam model are

Total expenditure elasticities: $$\eta_i = \frac{\theta_i}{w_i} \tag{6-24}$$

Uncompensated cross-price elasticities: $$\varepsilon_{ij} = \frac{\pi_{ij} - \theta_i w_j}{w_i} \tag{6-25}$$

Compensated cross-price elasticities: $$\varepsilon_{ij}^{*} = \frac{\pi_{ij}}{w_i} \tag{6-26}$$

Theoretical demand restrictions for the Rotterdam model are

[12] Only if the price coefficients were restricted to sum to zero, they could be interpreted as compensated elasticities (Alston et al., 2002).

Adding-up: $\sum_i \theta_i = 1 \qquad \sum_i \pi_{ij} = 0$

Homogeneity: $\sum_j \pi_{ij} = 0$

Symmetry: $\pi_{ij} = \pi_{ji}$ (6-27)

Provided the data add up, the adding-up restriction on the Rotterdam model is automatically satisfied so that the sum of the dependent variables in Equation (6-22) will equal the first independent variables. The homogeneity and symmetry restrictions can be imposed and tested equation by equation.

The Rotterdam model in Equation (6-22) was estimated for the fresh tomato monthly data from 1990 to 2001. The homogeneity and symmetry restrictions were imposed. The result of the SUR estimation is summarized in Table 6-8. Due to symmetry, the bottom half is a mirror image of the top half. The Rotterdam demand system was estimated three times and one equation was dropped for avoiding singularity problem at each time of estimation. Own price variable exhibits a statistically significant effect in demand equations of U.S., Mexican, and Canadian tomatoes. The expenditure variable is statistically significant in all three equations.

Elasticities at the sample mean were calculated from the parameter estimates and the results are in Table 6-9 and Table 6-10.[13] Uncompensated own-price elasticities are negative except in CD equation. All-own price parameters along the diagonal in all three equations are negative as expected, implying as the price of fresh tomatoes increases, the amount of fresh tomato quantity demanded declines. All compensated own-price elasticities are negative and inelastic (-0.1530, -0.3323, and -0.6507). These results indicate that if the price of U.S. fresh tomatoes drops by 1%, the quantity demanded

[13] Calculated elasticities for the Rotterdam model are conditional since this study used a conditional Rotterdam model.

would increase by 0.15%; if the price of Mexican tomatoes decreases by 1%, the quantity demanded would increase by 0.33%; and if the price of Canadian tomatoes declines by 1%, the quantity demand will rise by 0.65%. Positive compensated cross-price elasticities indicate that U.S and Mexican tomatoes are pairwise substitutes and so are U.S. and Canadian tomatoes. Substitution relationship also exists between Mexican and Canadian tomatoes.

Almost ideal demand system (AIDS)

An AIDS specification is as the following:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left(\frac{E}{P}\right) \tag{6-28}$$

where $\log P$ is a price index defined as

$$\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \frac{1}{2}\sum_k \sum_l \gamma_{kl} \log p_k \log p_l \tag{6-29}$$

This research estimated two different empirical forms of the AIDS rather the original nonlinear AIDS model: Linear approximate AIDS and first difference AIDS.

Linear approximate almost ideal demand system (LA/AIDS): A LA/AIDS specification is as the following:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left(\frac{E}{P^*}\right) \tag{6-30}$$

where $\log P^*$ can be Stone's price index defined as

$$\log P^* = \sum_k w_k \log p_k \tag{6-31}$$

However, the approximation properties of the LA/AIDS may be seriously affected by the fact that the Stone price index is not invariant to the arbitrary choice of units of

measurement for prices and quantities (Moschini, 1995).[14] In this research, the modified Stone price index (or the log linear analogue of the Paasche price index) was used:

$$\log P^{\bullet} = \sum_k w_k \log\left(\frac{p_k}{p_0}\right) \tag{6-32}$$

where p_0 denotes the price of the base period.

First difference almost ideal demand system (FD/AIDS): A FD/AIDS specification is as the following:

$$\Delta w_i = \beta_i \Delta \log\left(\frac{E}{P}\right) + \sum_j \gamma_{ij} \Delta \log p_j \tag{6-33}$$

The FD/AIDS was estimated also using the modified Stone price index in Equation (6-32). The corresponding elasticities for the AIDS are

Total expenditure elasticities:

$$\eta_i = 1 + \frac{\beta_i}{w_i} \tag{6-34}$$

Uncompensated cross-price elasticities:

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \beta_i\left(\frac{w_j}{w_i}\right)$$

$$\text{where} \quad \delta_{ij} = \begin{cases} 1 & \text{if} \quad i = j \\ 0 & \text{otherwise} \end{cases} \tag{6-35}$$

Compensated cross-price elasticities:

$$\varepsilon_{ij}^{*} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} + w_j$$

$$\text{where} \quad \delta_{ij} = \begin{cases} 1 & \text{if} \quad i = j \\ 0 & \text{otherwise} \end{cases} \tag{6-36}$$

Theoretical demand restrictions for the LA/AIDS and FD/AIDS are

[14] Moschini illustrate an example in his paper: By changing the units of the first good from pounds to kilograms, one would scale the corresponding price by the conversion rate between the two units (1kg = 2.21 pound). Because such a change does not affect expenditure shares, the Stone index would apply unchanged weights to scaled prices.

Adding-up: $\sum_i \alpha_i = 1$[15] $\sum_i \beta_i = 0$ $\sum_i \gamma_{ij} = 0$

Homogeneity: $\sum_j \gamma_{ij} = 0$

Symmetry: $\gamma_{ij} = \gamma_{ji}$ (6-37)

The LA/AIDS was estimated for fresh tomatoes using monthly data form 1990 to 2001. The restrictions of homogeneity and symmetry were maintained. Table 6-11 presents the SUR estimates of the restricted LA/AIDS. Like estimating the Rotterdam demand system, the LA/AIDS was estimated three times to recover standard errors of the parameters of dropped equation. Own price variables exhibit statistically significance in demand equations of U.S., Mexican, and Canadian tomatoes. Coefficients of the expenditure variable are statistically significant and plausible except for the MX demand equation.

Uncompensated and compensated elasticities were calculated at the sample mean using the parameter estimates of the restricted LA/AIDS (Tables 6-12 and 6-13). All own-price elasticities show negative signs. Most of expenditure elasticities are positive. U.S. and Mexican fresh tomatoes and U.S. and Canadian fresh tomatoes show pairwise substitute relationship. The compensated cross-price elasticities between U.S. and Mexican tomatoes of the LA/AIDS are less than those of the Rotterdam model, while the compensated cross-price elasticities between U.S. and Canadian tomatoes of the LA/AIDS are greater than those of the Rotterdam model.

Table 6-14 presents the parameter estimates of the restricted FD/AIDS with homogeneity and symmetry restrictions. The number of statistically significant variables

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[15] $\sum_i \alpha_i = 1$ restriction is only for the LA/AIDS. This restriction is unnecessary for the FD/AIDS since the FD/AIDS does not have an intercept.

decreased in the restricted FD/AIDS.[16] Calculated uncompensated and compensated elasticities from the parameter estimates of the restricted FD/AIDS are shown in Tables 6-15 and 6-16. All own-price elasticities are negative as expected and statistically significant at the 5% significance level. Most of expenditure elasticities are positive except for the MX equation.

U.S. and Mexican fresh tomatoes and U.S. and Canadian fresh tomatoes show pairwise substitute relationship in the restricted FD/AIDS. The compensated cross-price elasticity of Mexican fresh tomatoes with respect to U.S. domestic fresh tomatoes (0.3816) is greater than that of U.S. domestic fresh tomatoes with respect to Mexican fresh tomato imports (0.1794). This indicates that the price of U.S. domestic fresh tomatoes affects the expenditure share of Mexican fresh tomato imports, while the price of Mexican tomato imports does not have such an influence on the expenditure share of U.S. domestic fresh tomatoes. This explanation is true for the restricted Rotterdam model and LA/AIDS.

Simulation Using COMPAS

Demand models for fresh tomatoes in United States were estimated in the previous section. Using the parameter estimates from each model, price elasticities were calculated that are required for the COMPAS analysis. In this section, the COMPAS model is simulated in order to evaluate the effect of change in elasticity of substitution. Rather interested in actual effects of dumping on the U.S. domestic industry, this research aims at comparing the magnitude of changes resulted from each simulation, because its

[16] All of the parameter estimates of the restricted Rotterdam model were statistically significant. 11 out of 12 (92%) parameter estimates of the restricted LA/AIDS were statistically significant. So were 5 out of 9 (56%) parameter estimates of the restricted LA/AIDS.

principal object is to analyze how the COMPAS result affects by the selection of various values of elasticity of substitution.

Under the assumption that all other input parameters – dumping margin, elasticities of demand and supply – are constant, only the value of elasticity of substitution changes in each COMPAS simulation. Compensated cross-price elasticities brought by the empirical demand analysis are employed into the COMPAS model as an alternative to elasticity of substitution. Table 6-17 summarizes the value of elasticity of substitution and cross-price elasticities that are used for the simulation.

As described before, the U.S. ITC believed that there exists a moderate degree of substitution between U.S. domestic fresh tomatoes and Mexican fresh tomato imports (i.e., σ=1 to 3). Since COMPAS only manages discrete numbers, the range is treated as if there are three cases: when σ=1, 2, and 3. The estimated elasticity of substitution is also considered. That is 1.1076, which was obtained by imposing the full Armington assumptions in the double-log demand model. Instead COMPAS calculates cross-price elasticities by itself given elasticity of substitution, empirically estimated cross-price elasticities are directly input into the system. They are compensated cross-price elasticities from the double-log demand model, Rotterdam model, linear approximate AIDS (LA/AIDS), and first difference AIDS (FD/AIDS) restricted by with homogeneity and symmetry. Totally, the COMPAS model is simulated 8 times.

Figures 6-2 through 6-5 show the percentage changes in domestic price, output, revenue, and capacity utilization caused by dumping under the 8 scenarios constructed with various value of elasticity of substitution. When the COMPAS model is applied to an empirical analysis, every input parameter plays a role in determining pooled impacts

of dumping onto the domestic industry. However, this research assumed that only the value of elasticity of substitution decides the scale of changes occurred by dumping. Every figure presents similar aspects in terms of the direction of changes: Negative changes in domestic price, output, revenue, and capacity utilization in the presence of dumping are as expected.

As a result of several experimental simulations, elasticity of substitution less than a certain numerical value always produces positive changes in variables – price, output, revenue, and capacity utilization – explaining the condition of domestic industry. In other words, when the elasticity of substitution is less than the certain value or is "low" quoted from the U.S. ITC's definition, the COMPAS results indicate that dumping does not cause harm or injury to the domestic industry. In this research, that marginal value is 0.43.[17] [18]

The U.S. ITC put the range of 1 to 3 in one category of degree of substitution that is classified as "moderate". However, if σ = 2 or 3, the effects generated by the COMPAS model are huge compared with those COMPAS simulation results using empirical estimates of either the estimate of elasticity of substitution or compensated cross-price elasticities. Empirical estimation of demand for fresh tomatoes in the United States shows that the elasticity of substitution between U.S. and Mexican tomatoes is

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[17] As discussed before, the numerical value of 0.43 was found from several experimental COMPAS simulations. 0.43 is a base line where dumping causes harm or injury to the domestic industry under the assumption that every other input parameters are held constant at the hypothetical dumping margin = 17%; domestic market value share = 65%; import market value share = 31%; domestic content = 100%; and domestic capacity utilization = 100%. If those values of other input parameters change, the base line may also change.

[18] This result may be a "Henning conundrum" case. That is, if the elasticity of substitution is smaller than aggregate demand elasticity (so that the aggregate price effects dominate cross-price effects), then competing goods will be net complements instead of net substitutes (Francois and Hall, 1997).

around 1, raising a concern in the use of behavioral estimates of elasticity of substitution far from the empirical circumstances. It may also suggest that it is necessary for modifying the range of degree of substitution set by the U.S. ITC.

Generally, the COMPAS simulations using compensated cross-price elasticities from the double-log model generate the largest effects on the domestic industry by dumping among the COMPAS analyses reproduced by empirical estimates of elasticities. The results may be affected by the fact that the cross-price elasticity for U.S. tomatoes with respect to Mexican tomatoes is positive (or substitute) while the elasticity for Mexican tomatoes with respect to U.S. tomatoes is negative (or complementary) in the double-log demand model for fresh tomatoes.

Summary

The COMPAS model is used to analyze the impact of unfair trade to the domestic industry. The underlying structure of COMPAS is an Armington type of imperfect substitute trade model and elasticity of substitution is a major input parameter for the COMPAS simulation in determining the effects of dumping. The elasticity of substitution can be obtained from estimation in the literature or from empirical estimation of the elasticity. Generally, the U.S. ITC uses behavioral estimates of elasticity of substitution that came from related studies but may not have been calculated for the same data or the same time period. Constructed by those values, the range of degree of substitution turned out inappropriate for the U.S. fresh tomato industry. It is significantly different from empirical estimates of this research. These results indicate that the U.S. ITC's range of "moderate" degree of substitution (1 to 3) is too broad and in need of modification.

Assuming that input parameters other than elasticity of substitution remain constant, the elasticity of substitution less than a certain numerical value was found to bring

contrary COMPAS simulation results. That is, if there exists a relatively small degree of substitution between domestic and import products (particularly elasticity of substitution is less than aggregate demand elasticity), COMPAS produces such a result that dumping (or unfair trade) does not cause injury or harm to the domestic industry.

Finally, three empirical demand models were estimated with or without theoretical demand restrictions: the double-log demand model, Rotterdam model, and linear and first difference version of the AIDS. Compensated cross-price elasticities calculated from the parameter estimates of each model were used as input parameters for the COMPAS analysis. Which demand model can explain best for the current U.S. fresh tomato industry was not determined. Model choice and specification for the given data are potential tasks to do in advising more efficient policy implications.

Table 6-1. Correlation matrix of prices for domestic and imported tomatoes

	USP	USP(-1)	MXP	CDP
USP	1			
USP(-1)*	0.4949	1		
MXP	0.3813	0.6718	1	
CDP	0.3266	0.1421	0.3167	1

* USP(-1) is a lag transformation of USP.

Table 6-2. Summary statistics of domestic and imported tomato expenditure shares

Origin	Mean	Std Dev	Minimum	Maximum
U.S.	0.6497	0.2014	0.1164	0.9718
Mexico	0.3055	0.2036	0.0257	0.8829
Canada	0.0449	0.0614	0	0.2546

Source: Calculated by the author.

Table 6-3. Ranges and maximum values for elasticities required in COMPAS

Elasticity[19]		Low	Moderate	High	Max
Supply	φ_D , φ_S	Less than 1	1 to 3	Greater than 3	8
Aggregate Demand	ε_Q	0 to -0.4	-0.5 to –1	Less than -1	-3
Substitution	σ	Less than 1	1 to 3	Greater than 3	8

Source: Featherstone, D. (1995) "COMPAS Data Requirements." p.12.

[19] The same notations for elasticities are used as Chapter 4. φ_D and φ_S are the elasticity of supply of the domestic product and that of the import, respectively. ε_Q is the elasticity of demand for the composite good. σ is the elasticity of substitution between domestic products and imports.

Table 6-4. Chi-square (χ^2) statistics for hypothesis tests using double-log demand model

	Test Statistics	d.f. [c]
Separability	98.905 *	56
Homotheticity	361.150 *	8
H&S [a]	235.421 *	71
Armington [b]	301.942 *	64

[a] H&S denotes the joint restriction of homothetic separability.

[b] "Armington" denotes the full set of Armington restrictions – homotheticity, separability, and equality of own price coefficients ($\gamma_{ii} = \gamma_{jj} \ \forall \ i, j$).

[c] d.f. (i.e., degree of freedom) for the LR test that equals the number of restrictions are as follows (Alston et al., 1990):

Separability:	$n^2 - n$
Homotheticity:	n
H&S:	n^2
Armington:	$n^2 + n - 1$

* indicates a rejection of the null hypothesis that the model is correct at the 5% significance level ($p = 0.05$).

Table 6-5. Parameter estimates of double-log demand model

Eq.[a]	Intercept	US	MX	CD	Exp[20]
US	-1.2995	-0.1136	0.3943*	-0.2806*	0.7702*
	(1.8549)	(0.0980)	(0.1013)	(0.1007)	(0.1609)
MX	-8.5920*	-0.3035*	-0.6599*	0.9634*	1.3152*
	(2.8757)	(0.1519)	(0.1571)	(0.1561)	(0.2494)
CD	-76.3482*	1.4585*	1.6064*	-3.0649*	6.8758*
	(6.5589)	(0.3464)	(0.3582)	(0.3560)	(0.5688)

[a] Abbreviations:

Eq.: Equation name
US: Coefficient of U.S. prices
MX: Coefficient of Mexican prices
CD: Coefficient of Canadian prices
Exp: Coefficient of expenditure variable

* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

[20] As noted by LaFrance (1991), when the expenditure variable is constructed from the price and quantity data (as done in this research), it is correlated with the error term in a quantity- or budget share-dependent demand equation. This means that it may not be appropriate to treat the expenditure variable as exogenous. However, this research treats the expenditure variable as exogenous.

Table 6-6. Uncompensated price and expenditure elasticities for double-log demand model (at the sample mean)

Eq. [a]	US	MX	CD	Exp
US	-0.6140*	0.1590	-0.3152*	0.7702*
	(0.1160)	(0.1197)	(0.0072)	(0.1609)
MX	-1.1580*	-1.0617*	0.9044*	1.3152*
	(0.1798)	(0.1856)	(0.0112)	(0.2494)
CD	-3.0085*	-0.4939	-3.3734*	6.8758*
	(0.4100)	(0.4234)	(0.0255)	(0.5688)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-7. Compensated price elasticities for double-log demand model (at the sample mean)

Eq. [a]	US	MX	CD
US	-0.1136	0.3943*	-0.2806*
	(0.0980)	(0.1013)	(0.1007)
MX	-0.3035*	-0.6599*	0.9634*
	(0.1519)	(0.1571)	(0.1561)
CD	1.4585*	1.6064*	-3.0649*
	(0.3464)	(0.3582)	(0.3560)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-8. Parameter estimates of restricted Rotterdam model with homogeneity and symmetry

Eq. [a]	US	MX	CD	Exp
US	-0.0997*	0.0855*	0.0143*	0.6939*
	(0.0231)	(0.0241)	(0.0063)	(0.0664)
MX		-0.1006*	0.0151*	0.2630*
		(0.0264)	(0.0076)	(0.0707)
CD			-0.0294*	0.0431*
			(0.0082)	(0.0161)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-9. Uncompensated price and expenditure elasticities for restricted Rotterdam model with homogeneity and symmetry (at the sample mean)

Eq. [a]	US	MX	CD	Exp
US	-0.8468*	-0.1910*	-0.0262*	1.0640*
	(0.0678)	(0.0531)	(0.0107)	(0.1019)
MX	-0.2843	-0.5954*	0.0107	0.8690*
	(0.1553)	(0.1236)	(0.0267)	(0.2335)
CD	-0.3061	0.0460	-0.6938*	0.9538*
	(0.2418)	(0.2093)	(0.1836)	(0.3569)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-10. Compensated price elasticities for restricted Rotterdam model with homogeneity and symmetry (at the sample mean)

Eq. [a]	US	MX	CD
US	-0.1530*	0.1311*	0.0219*
	(0.0354)	(0.0369)	(0.0097)
MX	0.2824*	-0.3323*	0.0500*
	(0.0796)	(0.0873)	(0.0251)
CD	0.3159*	0.3347*	-0.6507*
	(0.1405)	(0.1678)	(0.1816)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-11. Parameter estimates of restricted LA/AIDS with homogeneity and symmetry

Eq. [a]	Intercept	US	MX	CD	Exp
US	-3.4628*	0.1856*	-0.1712*	-0.0144	0.3282*
	(0.8816)	(0.0418)	(0.0376)	(0.0131)	(0.0701)
MX	5.9332*		0.1130*	0.0582*	-0.4518*
	(0.8156)		(0.0369)	(0.0135)	(0.0648)
CD	-1.4705*			-0.0438*	0.1236*
	(0.2637)			(0.0137)	(0.0209)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-12. Uncompensated price and expenditure elasticities for restricted LA/AIDS with homogeneity and symmetry (at the sample mean)

Eq. [a]	US	MX	CD	Exp
US	-1.0425*	-0.4178*	-0.0448*	1.5051*
	(0.0881)	(0.0707)	(0.0209)	(0.1078)
MX	0.4004*	-0.1782	0.2567*	-0.4790*
	(0.1707)	(0.1456)	(0.0450)	(0.2121)
CD	-2.1102*	0.4545	-2.0985*	3.7542*
	(0.3989)	(0.3516)	(0.3037)	(0.4649)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-13. Compensated price elasticities for restricted LA/AIDS with homogeneity and symmetry (at the sample mean)

Eq. [a]	US	MX	CD
US	-0.0647	0.0420	0.0227
	(0.0643)	(0.0578)	(0.0202)
MX	0.0892	-0.3245*	0.2352*
	(0.1230)	(0.1208)	(0.0441)
CD	0.3288	1.6012*	-1.9305*
	(0.2925)	(0.3002)	(0.3042)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-14. Parameter estimates of restricted FD/AIDS with homogeneity and symmetry

Eq. [a]	US	MX	CD	Exp
US	0.0852*	-0.0819*	-0.0033	0.3279*
	(0.0174)	(0.0182)	(0.0051)	(0.0451)
MX		0.0699*	0.0119	-0.3472*
		(0.0202)	(0.0063)	(0.0483)
CD			-0.0086	0.0193
			(0.0068)	(0.0118)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-15. Uncompensated price and expenditure elasticity for restricted FD/AIDS with homogeneity and symmetry (at the sample mean)

Eq. [a]	US	MX	CD	Exp
US	-1.1967*	-0.2802*	-0.0278*	1.5047*
	(0.0511)	(0.0361)	(0.0031)	(0.0694)
MX	0.4704*	-0.4239*	0.0901*	-0.1365
	(0.1157)	(0.0840)	(0.0071)	(0.1580)
CD	-0.3533	0.1352	-1.2111*	1.4292*
	(0.1990)	(0.1630)	(0.1530)	(0.2626)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-16. Compensated price elasticity for restricted FD/AIDS with homogeneity and symmetry (at the sample mean)

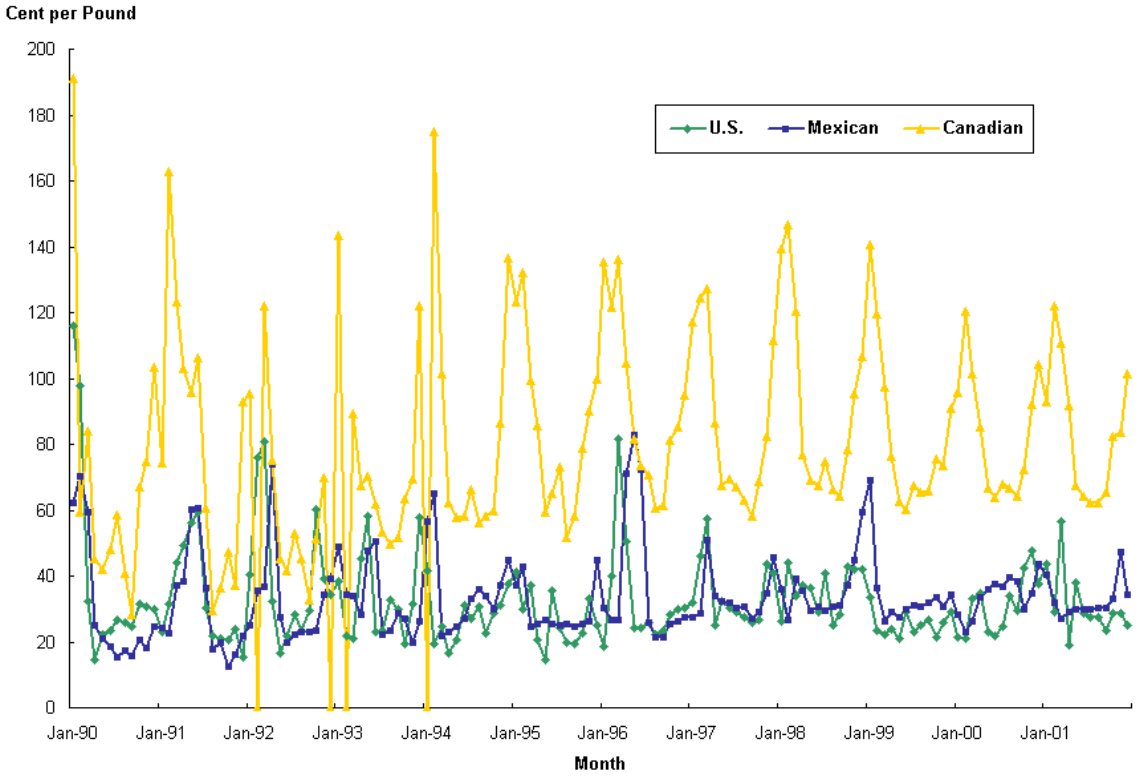
Eq. [a]	US	MX	CD
US	-0.2192*	0.1794*	0.0397*
	(0.0268)	(0.0281)	(0.0079)
MX	0.3816*	-0.4656*	0.0840*
	(0.0597)	(0.0662)	(0.0206)
CD	0.5752*	0.5717*	-1.1469*
	(0.1146)	(0.1403)	(0.1521)

[a] Abbreviations are the same with the previous table.
* indicates a coefficient that is significantly different from zero at the 5% significance level ($p = 0.05$). Estimates in parentheses are standard errors.

Table 6-17. Elasticity of substitution and cross-price elasticities used for the COMPAS simulation

Source	Elasticity of Substitution (σ)	Cross-Price Elasticity [a] US vs. MX (ε_{ij})	MX vs. US (ε_{ji})
U.S. ITC	1 to 3		
Armington	1.1076		
Double-Log		0.3943	-0.3035
Rotterdam with H&S [b]		0.1311	0.2824
FD/AIDS with H&S		0.1794	0.3816
LA/AIDS with H&S		0.0420	0.0892

[a] Cross-price elasticities were used since elasticity of substitution could not be estimated directly from the double-log model, Rotterdam model, LA/AIDS, and FD/AIDS.
[b] H&S means maintaining homogeneity and symmetry restrictions.



Source: ERS, 2003b and Global Trade Information Services, Inc.

Figure 6-1. Monthly prices for U.S., Mexican, and Canadian fresh tomatoes (1990-2001)

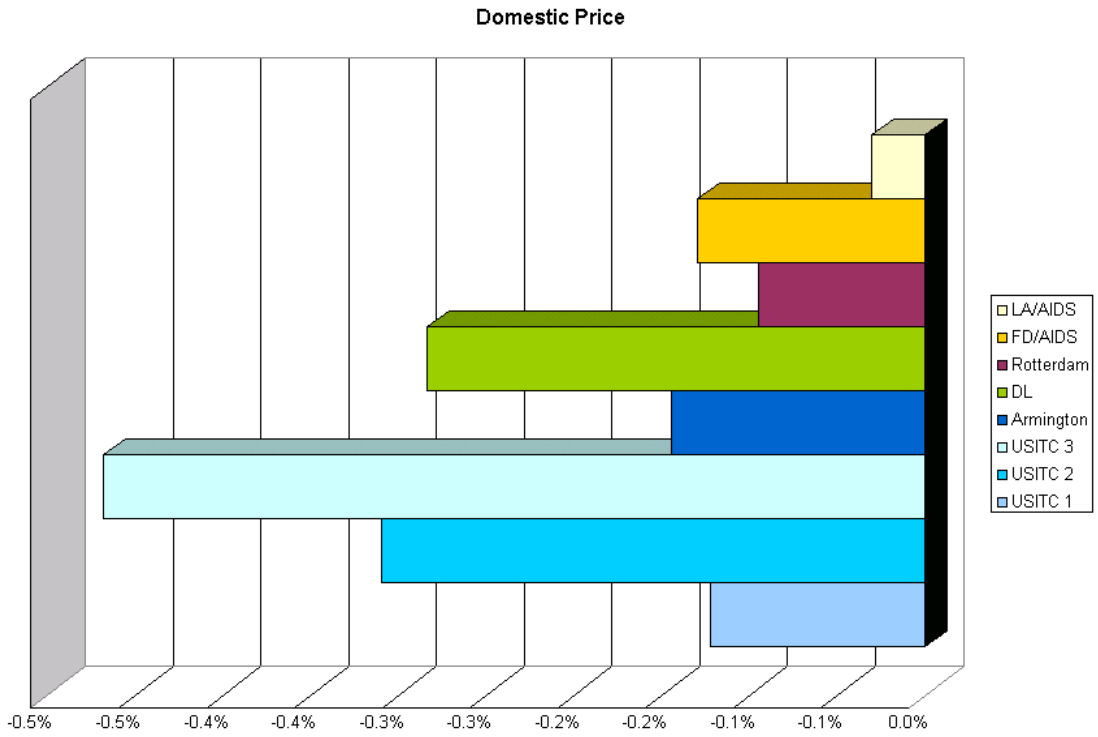


Figure 6-2. COMPAS simulation: Change in domestic price by dumping

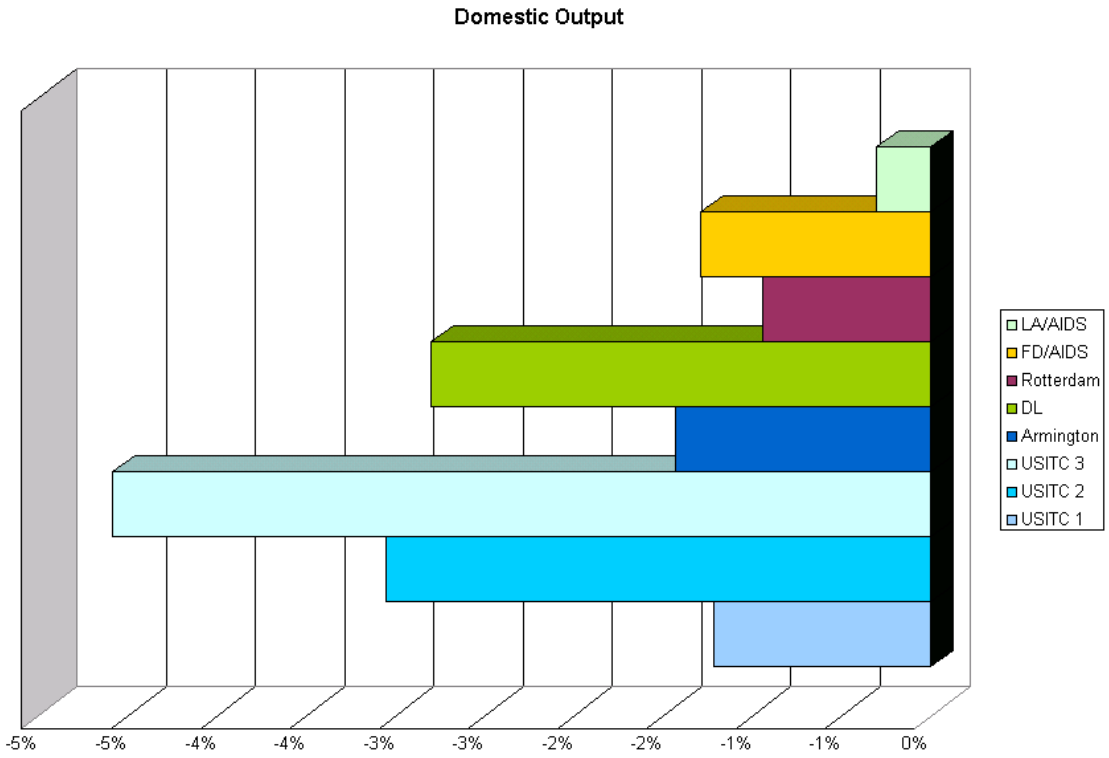


Figure 6-3. COMPAS simulation: Change in domestic output by dumping

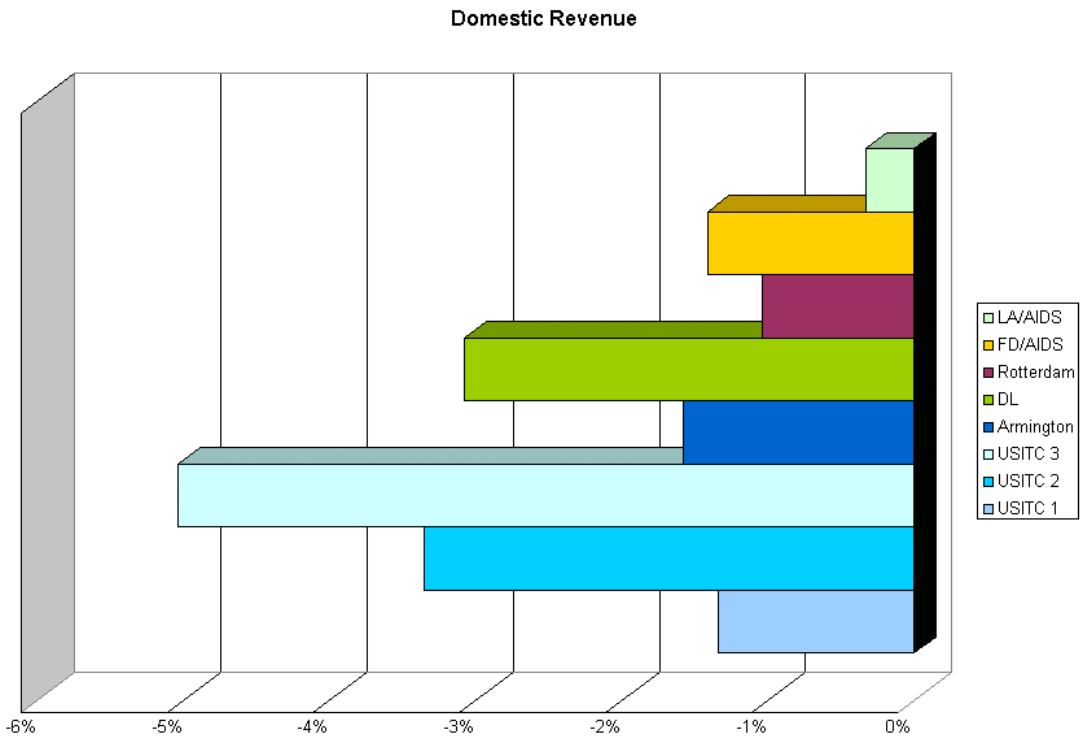


Figure 6-4. COMPAS simulation: Change in domestic revenue by dumping

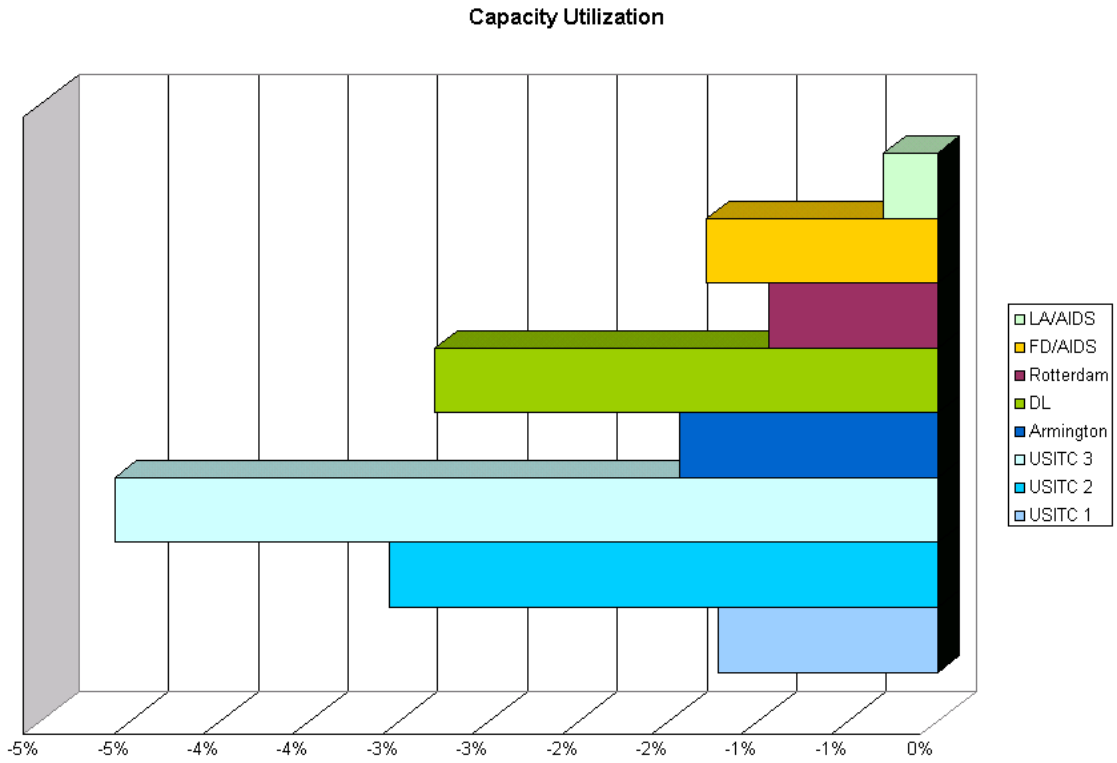


Figure 6-5. COMPAS simulation: Change in capacity utilization by dumping

CHAPTER 7
SUMMARY AND CONCLUSION

International trade and globalization have significant impacts on U.S. agriculture. With the growing productivity of agriculture, U.S. producers rely heavily on export markets. Enjoying a variety of food and a year-round supply of fresh fruit and vegetables, consumers benefit from increased imports. Recently, since the implementation of NAFTA, which was effective on January 1, 1994, U.S. agricultural trade with Mexico and Canada has expanded. Accordingly, each country has been involved in agricultural trade disputes concerning unfair trading practices.

An antidumping duty is imposed if imports are being sold for less than their fair value (LTFV) and those imports are causing or threaten to cause material injury to the corresponding domestic industry. The aspects of antidumping duty have been incorporated into U.S. law at Subtitle VII of the Tariff Act of 1930 as amended. Recently, Byrd Amendment was enacted on October 28, 2000 so that the U.S. Customs annually distributes duties to domestic producers who supported the petition for the antidumping (or countervailing) duty orders.

The U.S. antidumping laws attempt to remedy the injured domestic industry by imposing an additional duty on the dumped imports with the purpose of ensuring fair trade. To impose extra duties for dumping, the U.S. Department of Commerce (DOC) first must find that the imports are being sold in the United States at prices below normal value and report the dumping margin. Next, the U.S. International Trade Commission

(ITC) analyzes the effects of dumping and determines that the subject imports of the investigation are causing material injury to the domestic industry.

The main objective of this research was to critique and evaluate Commercial Policy Analysis System (COMPAS) that the U.S. ITC uses in order to analyze the impact of unfair trade to specific domestic industries. It is not used in a conclusive way, but the COMPAS analysis takes part as guidance to the U.S. ITC's final decision. The underlying structure of COMPAS is an Armington type imperfect substitute trade model. An Armington model assumes that import demands are separable among import sources (separability); elasticities of substitution between all pairs of products within a group are constant (single CES); and the size of the market does not affect each country's market share (homotheticity). The Armington model has been applied widely for the analysis of trade policy changes; however its assumptions are strong restrictions for practical application.

This research used monthly data from 1990 to 2001 for the U.S. fresh tomato industry. Import sources in consideration were Mexico and Canada. There were two Section 201 cases and an antidumping case regarding fresh tomato imports from Mexico. Both Section 201 investigations terminated with no injury determination by reason of increased imports. The injury requirement under Section 201 is considered to be more difficult than those of antidumping duty statutes. Section 201 requires that the injury be serious and that the increased imports must be a substantial (or important) cause of the serious injury while the injury standard in antidumping duty cases requires harm which is not inconsequential, immaterial, or unimportant. Currently, the antidumping investigation of 1995 is still effective by a new suspension agreement in 2002.

The consistency of fresh tomato data with theory of utility maximization was tested using a nonparametric approach. The data satisfied the general axiom of revealed preference (GARP). The parametric Armington restrictions were also tested using a double-log functional form and comprehensively rejected for fresh tomato data implying that the COMPAS analysis based on the Armington assumptions may not explain correctly the effects of dumping at least for the domestic industry of fresh tomatoes in the United States.

COMPAS is a package of standardized spreadsheets run on Quattro Pro or Microsoft Excel. Each spreadsheet requires certain user-provided data. Those are margin of dumping, average tariff rate, value shares of domestic and import products, domestic capacity utilization, and various price elasticities such as elasticity of supply of domestic and import products, elasticity of demand, and most importantly, elasticity of substitution. Elasticities are obtained from either the existing literature or from empirical estimation. The U.S. ITC set the range of degree of substitution or price responsiveness constructed by related studies that may be done on the time periods different from the time period concerned in a current investigation, or on even not the exact same product.

Estimation of elasticity of substitution was attempted by imposing the full Armington restrictions into the double-log demand model. The estimate is 1.1076, which is in the U.S. ITC's range of degree of substitution between U.S. fresh tomatoes and imports from Mexico (i.e., $1 \leq \sigma \leq 3$). This empirical estimate suggests that the U.S. ITC's range of degree of substitution for the U.S. fresh tomato industry was set inappropriately in that the range is too broad to categorize together.

To obtain empirical estimates that represent the substitution relationship between two products, this research econometrically estimated demand models for fresh tomato data. Those were the double-log demand model, Rotterdam model, and linear and first difference version of the AIDS with theoretical demand restrictions of homogeneity and symmetry. Estimation of those demand models allowed calculating price elasticities. Uncompensated and compensated elasticities were calculated at the sample mean using the parameter estimates of each demand model. Particularly, compensated cross-price elasticities were used as direct input parameters for COMPAS.

Typically, a COMPAS simulation needs an elasticity of substitution, and then, using the elasticity of substitution, the COMPAS model calculates for itself cross-price elasticities that are essential for evaluating an effect on specific industries by a change in prices caused by dumping. However, as developed in Chapter 4, the COMPAS algorithm calculating cross-price elasticities from the value of elasticity of substitution works right only if the Armington assumptions are satisfied. As in this research, in such a case that a given data does not satisfy the Armington restrictions, it is not correct that one lets COMPAS estimate cross-price elasticities from the elasticity of substitution.

Measuring actual effects of the dumping on the U.S. domestic industry is secondary in this research. Rather, this research aims at comparing the magnitude of changes in each COMPAS simulation resulted from the selection of various value of elasticity of substitution. Therefore, other input parameters excluding elasticity of substitution remained the same. Figures 6.2-6.5 in Chapter 6 illustrated and compared the effects of dumping on domestic price, output, revenue, and capacity utilization, respectively, simulated 8 times only by change in the value of elasticity of substitution. Every figure

showed similar aspects in terms of the direction of changes: Negative changes in domestic price, output, revenue, and capacity utilization occurred in the presence of dumping. Furthermore, among the different COMPAS simulations in each figure, the results from 5 simulations were comparable. Those 5 cases are $\sigma = 1$ (the lower bound of the U.S. ITC range of degree of substitution); estimate of the Armington model (1.1076); and compensated cross-price elasticities from the restricted Rotterdam model, FD/AIDS, and LA/AIDS. It implies that the elasticity of substitution in the U.S. fresh tomato industry is not much greater than 1.

An experimental COMPAS simulation was performed to check whether there exists a value for the elasticity of substitution that produces positive effects on the condition of domestic industry by dumping. Assuming that other input parameters required for the COMPAS analysis remain the same as given, a positive numerical value of 0.43 for the elasticity of substitution was found to result in positive effects of dumping on the domestic industry. It indicates that if elasticity of substitution is less than a certain value (that value may be aggregate demand elasticity), the COMPAS analysis produces results that the unfair trade does not cause injury or harm to the domestic industry.

The COMPAS model is simple to use with a relatively small number of input parameters and its output result is straightforward for interpreting the effects of unfair trade on the domestic industry of concern. As pointed out, the strong Armington assumptions behind COMPAS should be tested for each case. If the restrictions are not satisfied, one should provide cross-price elasticities from empirical studies. However, even if cross-price elasticities are provided, the reliability of COMPAS analyses is still in question since model specification based on the Armington structure is problematic.

COMPAS could create false direction of change and therefore, it could provide wrong policy suggestions. It is necessary to adjust COMPAS that can be compatible with flexible functional forms.

An inverse demand approach can be used for obtaining cross-price elasticities for fresh tomatoes since the data available for fresh tomatoes are not individual household data but producers' or importers' shipment price and quantity data. Several studies tried to apply the inverse demand approach for analyzing demand for agricultural products, but none were completed for the demand for fresh tomatoes (Brown et al., 1995; Eales et al., 1997; Voorthuizen et al., 2001). Elasticity of substitution could not be derived directly from empirical demand models for fresh tomatoes. Instead, this research used cross-price elasticities. Some state that elasticity of substitution is a terminology for production analysis and for demand analysis the concept of cross-price elasticity is employed. Nevertheless, developing such a method would be a contribution for future research.

APPENDIX
THEORETICAL DEMAND RESTRICTIONS

Assume the following demand functions giving quantities as a function of prices and total expenditures:

$$q_i = g_i(E, p) \tag{A-1}$$

This relationship is referred to as *Marshallian* demand function. Also its dual, *Hicksian* or *compensated* demand function is defined as a function of prices and utility level:

$$q_i = h_i(u, p)^1 \tag{A-2}$$

Now, the theoretical demand restrictions are adding-up, homogeneity, and symmetry.[2]

Adding-up: The adding-up restriction says that the total value of both Hicksian and Marshallian demands is total expenditure:

$$\sum_k p_k h_k(u, p) = \sum_k p_k g_k(E, p) = E \tag{A-3}$$

That is, the demand functions satisfy the budget constraint. It is useful to express (A-3) as restrictions on the derivatives of the demand functions, rather than on the function themselves (Deaton, 1980b). Then, the adding-up restriction implies that

---

[1] Original Problem

$$\underset{q}{Max} \quad u = v(q) \qquad \text{s.t.} \qquad p \cdot q = E$$

Dual Problem

$$\underset{q}{Min} \quad E = p \cdot q \qquad \text{s.t.} \qquad v(q) = u$$

[2] The last demand restriction is negativity, which is assumed to hold in this study.

$$\sum_k p_k \frac{\partial g_k}{\partial E} = 1 \qquad \sum_k p_k \frac{\partial g_k}{\partial p_i} + q_i = 0 \tag{A-4}$$

Adding-up requires that the marginal propensities to spend on each good sum to unity and that the net effect of a price change on the budget be zero.

(A-4) can be written in terms of Marshallian or *uncompensated* elasticities:

$$\sum_k w_k \eta_k = 1 \qquad \sum_k w_k \varepsilon_{ki} + w_i = 0 \tag{A-5}$$

where w_k is the budget share or $w_k = p_k q_k / E$. Likewise, $w_i = p_i q_i / E$. η_k is the total expenditure elasticity, i.e., $\eta_k = \partial \log g_k / \partial \log E$. ε_{ki} is the price elasticity (i.e., $\varepsilon_{ki} = \partial \log g_k / \partial \log p_i$). Specifically, if $k = i$, it is the own-price elasticity while if $k \neq i$, it is called cross-price elasticity.

Homogeneity: The Hicksian demands are homogeneous of degree zero in prices, the Marshallian demands in total expenditure and prices together.

$$h_i(u, \theta p) = h_i(u, p) = g_i(\theta E, \theta p) = g_i(E, p) \tag{A-6}$$

where θ is positive scalar. Since the Hicksian demands are the derivatives of a cost function, $c(u, p)$, homogeneous of degree one, those are homogeneous of degree zero. Rewriting (A-6) in terms of derivatives and elasticities, respectively,

$$\sum_k p_k \frac{\partial g_i}{\partial p_k} + E \frac{\partial g_i}{\partial E} = 0$$

$$\sum_k \varepsilon_{ik} + \eta_i = 0 \tag{A-7}$$

Homogeneity says that a proportionate change in p and E will leave purchases of good i unchanged.

Symmetry: The cross-price derivatives of the Hicksian demands are symmetric for all $i \neq j$,

$$\frac{\partial h_i(u,p)}{\partial p_j} = \frac{\partial h_j(u,p)}{\partial p_i}. \tag{A-8}$$

Since $h_i(u,p) = \partial c(u,p)/\partial p_i$ and $h_j(u,p) = \partial c(u,p)/\partial p_j$, (A1-8) can be expressed as follows:

$$\frac{\partial^2 c(u,p)}{\partial p_j \partial p_i} = \frac{\partial^2 c(u,p)}{\partial p_i \partial p_j} \text{ [3]} \tag{A-9}$$

To test (A1-8), it should be expressed in terms of the observable Marshallian demands through the following Slutsky equation:

$$\begin{aligned} s_{ij} &= \frac{\partial h_i}{\partial p_j} = \frac{\partial g_i}{\partial E} q_j + \frac{\partial g_i}{\partial p_j} \\ s_{ij} &= s_{ji} \end{aligned} \tag{A-10}$$

Rearranging the components of the Slutsky equation,

$$\frac{\partial g_i}{\partial p_j} = s_{ij} - \frac{\partial g_i}{\partial E} q_j \tag{A-11}$$

(A-11) implies that the uncompensated price response is decomposed into a substitution effect of the price change (s_{ij}) and an income effect of the price change ($-q_j\, \partial g_i / \partial E$). The Slutsky equation in elasticity form can be derived as follows:

$$\begin{aligned} &\left(\frac{\partial g_i / g_i}{\partial p_j / p_j}\right)\frac{g_i}{p_j} = s_{ij} - \left(\frac{\partial g_i / g_i}{\partial E / E}\right)\frac{g_i}{E} q_j \\ \rightarrow \quad &\left(\frac{\log g_i}{\log p_j}\right)\frac{g_i}{p_j} = s_{ij} - \left(\frac{\log g_i}{\log E}\right)\frac{g_i}{E} q_j \end{aligned}$$

[3] By Young's theorem, provided that continuous derivatives exist, two derivatives only different in the order of the double differentiation are identical.

$$\rightarrow \quad \varepsilon_{ij}\frac{g_i}{p_j} = s_{ij} - \eta_i q_j \frac{g_i}{E}$$

$$\rightarrow \quad \varepsilon_{ij} = s_{ij}\frac{p_j}{g_i} - \eta_i \frac{p_j q_j g_i}{g_i E}$$

$$\rightarrow \quad \varepsilon_{ij} = s_{ij}\frac{p_j}{g_i} - \eta_i \frac{p_j q_j}{E}$$

$$\rightarrow \quad \varepsilon_{ij} = s_{ij}\frac{p_j}{g_i} - \eta_i w_j$$

$$\rightarrow \quad \varepsilon_{ij} = \varepsilon_{ij}^{*} - \eta_i w_j \qquad \text{(A-12)}$$

where ε_{ij}^{*} is the compensated cross-price elasticity. The symmetry restriction can be also expressed in elasticity forms. From (A-12), we know $s_{ij} = \varepsilon_{ij}^{*}\frac{g_i}{p_j}$.

$$s_{ij} = s_{ji}$$

$$\rightarrow \quad \varepsilon_{ij}^{*}\frac{g_i}{p_j} = \varepsilon_{ji}^{*}\frac{g_j}{p_i}$$

$$\rightarrow \quad \varepsilon_{ij}^{*}\frac{g_i p_i}{E} = \varepsilon_{ji}^{*}\frac{g_j p_j}{E}$$

$$\rightarrow \quad \varepsilon_{ij}^{*} w_i = \varepsilon_{ji}^{*} w_j$$

or

$$[\varepsilon_{ij} + \eta_i w_j]w_i = [\varepsilon_{ji} + \eta_j w_i]w_j \qquad \text{(A-13)}$$

Next, to test or impose the above three theoretical demand restrictions on the demand models considered in Chapter 6, parameter restrictions are derived for each model in detail.

1. Double-log Demand Model

$$\log q_i = \alpha_i + \sum_j \gamma_{ij}\log\left(\frac{p_j}{P^*}\right) + \beta_i \log\left(\frac{E}{P^*}\right)$$

a. Elasticities

- Total expenditure elasticities:

$$\eta_i = \frac{\partial \log q_i}{\partial \log E} = \beta_i$$

- Uncompensated cross-price elasticities:

$$\begin{aligned}\varepsilon_{ij} &= \frac{\partial \log q_i}{\partial \log p_j} = \gamma_{ij} - \frac{\partial\left(\sum_j \gamma_{ij} \log P^*\right)}{\partial \log p_j} - \frac{\partial\left(\beta_i \log P^*\right)}{\partial \log p_j} \\ &= \gamma_{ij} - \beta_i w_j\end{aligned}$$

- Compensated cross-price elasticities:

$$\varepsilon_{ij}^{\ *} = \gamma_{ij}$$

b. Theoretical demand restrictions

i. Adding-up

From (A-5),

$$\sum_i w_i \eta_i = 1$$

$$\rightarrow \quad \sum_j w_i \beta_i = 1$$

$\rightarrow$ $\beta_i = 1$ or

At least one good for $\beta_i > 1$ and

at least one good for $\beta_i < 1$.[4]

---

[4] The double logarithmic specification of the budget share ($w_i = p_i q_i / E$) is

$$\log w_i = \log q_i + \log p_i - \log E$$

Substituting the double-log demand model into the above,

$$\log w_i = \alpha_i + (\gamma_{ii} + 1)\log p_i + (\beta_i - 1)\log E + \sum_{j \neq i} \gamma_{ij} \log p_j$$

The adding-up tells that either all the β_i is equal to unity or at least one of them must be larger than unity (Deaton and Muellbauer, 1980b).

$\rightarrow$ Cannot impose.[5]

ii. Homogeneity

From (A-7),

$$\sum_j \varepsilon_{ij} + \eta_i = 0$$
$$\rightarrow \quad \sum_j \left(\gamma_{ij} - \beta_i w_j\right) + \beta_i = 0$$
$$\rightarrow \quad \sum_j \gamma_{ij} - \beta_i + \beta_i = 0$$
$$\rightarrow \quad \sum_j \gamma_{ij} = 0$$

iii. Symmetry

From (A-13),

$$\varepsilon_{ij}{}^* w_i = \varepsilon_{ji}{}^* w_j$$
$$\rightarrow \quad \left(\gamma_{ij} - w_j \sum_j \gamma_{ij}\right) w_i = \left(\gamma_{ji} - w_i \sum_i \gamma_{ji}\right) w_j$$
$$\rightarrow \quad \gamma_{ij} w_i - w_i w_j \sum_j \gamma_{ij} = \gamma_{ji} w_j - w_i w_j \sum_i \gamma_{ji}$$

$\rightarrow$ Can't impose symmetry restriction

2. Rotterdam Model

$$w_i d \log q_i = \theta_i d \log Q + \sum_j \pi_{ij} d \log p_j$$

a. Elasticities

- Total expenditure elasticities:

$$\eta_i = \frac{\partial \log q_i}{\partial \log E} = \frac{\theta_i}{w_i}$$

[5] If $\beta_i = 1$, it implies identical expenditure patterns at all levels of total expenditure (i.e., homotheticity.) If there exists at least one luxury good for which $\beta_i > 1$ and at least one necessity for which $\beta_i < 1$, as total expenditure increases, total expenditures add up less than the budget or exceed the budget at some points (Deaton and Muellbauer, 1980b).

- Uncompensated cross-price elasticities:

$$\varepsilon_{ij} = \frac{\partial \log q_i}{\partial \log p_j} = \frac{\pi_{ij} - \theta_i w_j}{w_i}$$

- Compensated cross-price elasticities:

$$\varepsilon_{ij}^{*} = \varepsilon_{ij} + \eta_i w_j = \frac{\pi_{ij} - \theta_i w_j}{w_i} + \frac{\theta_i w_j}{w_i} = \frac{\pi_{ij}}{w_i}$$

b. Theoretical demand restrictions

i. Adding-up

From (A-5),

i)
$$\sum_i w_i \eta_i = 1$$
$$\rightarrow \quad \sum_i w_i \frac{\theta_i}{w_i} = 1$$
$$\rightarrow \quad \sum_i \theta_i = 1$$

ii)
$$\sum_i w_i \varepsilon_{ij} + w_j = 0$$
$$\rightarrow \quad \sum_i w_i \left(\frac{\pi_{ij} - \theta_i w_j}{w_i} \right) + w_j = 0$$
$$\rightarrow \quad \sum_i \pi_{ij} - w_j \sum_i \theta_i + w_j = 0$$
$$\rightarrow \quad \sum_i \pi_{ij} = 0$$

ii. Homogeneity

From (A-7),

$$\sum_j \varepsilon_{ij} + \eta_i = 0$$
$$\rightarrow \quad \sum_j \left(\frac{\pi_{ij} - \theta_i w_j}{w_i} \right) + \frac{\theta_i}{w_i} = 0$$
$$\rightarrow \quad \frac{1}{w_i} \sum_j \pi_{ij} - \frac{\theta_i}{w_i} \sum_j w_j + \frac{\theta_i}{w_i} = 0$$

$$\rightarrow \qquad \frac{1}{w_i}\sum_j \pi_{ij} = 0$$
$$\rightarrow \qquad \sum_j \pi_{ij} = 0$$

iii. Symmetry

From (A-13),

$$\varepsilon_{ij}{}^{*} w_i = \varepsilon_{ji}{}^{*} w_j$$
$$\rightarrow \qquad \left(\frac{\pi_{ij}}{w_i}\right) w_i = \left(\frac{\pi_{ji}}{w_j}\right) w_j$$
$$\rightarrow \qquad \pi_{ij} = \pi_{ji}$$

3. AIDS

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left(\frac{E}{P}\right),$$

where $\log P = \alpha_0 + \sum_k \alpha_k \log p_k + \frac{1}{2}\sum_k \sum_l \gamma_{kl} \log p_k \log p_l$ and

assume $\frac{\partial \log P}{\partial \log p_j} = \alpha_j + \sum_k \gamma_{kj} \log p_k$

$$\rightarrow \qquad w_i = \frac{p_i q_i}{E}$$
$$\rightarrow \qquad \log w_i = \log p_i + \log q_i - \log E$$
$$\rightarrow \qquad \log q_i = \log w_i - \log p_i + \log E$$

a. Elasticities

- Total expenditure elasticities:

$$\eta_i = \frac{\partial \log q_i}{\partial \log E} = \frac{\partial \log w_i}{\partial \log E} + 1 = \frac{\beta_i}{w_i} + 1$$

- Uncompensated cross-price elasticities:

$$\varepsilon_{ii} = \frac{\partial \log q_i}{\partial \log p_i} = \frac{\partial \log w_i}{\partial \log p_i} - 1 = \frac{1}{w_i}\left[\gamma_{ii} - \beta_i \frac{\partial \log P}{\partial \log p_i}\right] - 1$$
$$= \frac{1}{w_i}\left[\gamma_{ii} - \beta_i\left(\alpha_i + \sum_k \gamma_{ki} \log p_k\right)\right] - 1$$
$$= \frac{\gamma_{ii} - \beta_i\left(w_i - \beta_i \log(E/P)\right)}{w_i} - 1$$

$$\varepsilon_{ij} = \frac{\partial \log q_i}{\partial \log p_j} = \frac{\partial \log w_i}{\partial \log p_j} = \frac{1}{w_i}\left[\gamma_{ij} - \beta_i \frac{\partial \log P}{\partial \log p_j}\right]$$
$$= \frac{\gamma_{ij} - \beta_i\left(w_j - \beta_j \log(E/P)\right)}{w_i}$$

- Compensated cross-price elasticities:

$$\varepsilon_{ii}^{\ *} = \varepsilon_{ii} + \eta_i w_i = \frac{\gamma_{ii} - \beta_i\left(w_i - \beta_i \log(E/P)\right)}{w_i} - 1 + w_i + \frac{\beta_i w_i}{w_i}$$
$$= \frac{\gamma_{ii} + \beta_i \beta_i \log(E/P)}{w_i} + w_i - 1$$

$$\varepsilon_{ij}^{\ *} = \varepsilon_{ij} + \eta_i w_j = \frac{\gamma_{ij} - \beta_i\left(w_j - \beta_j \log(E/P)\right)}{w_i} + w_j + \frac{\beta_i w_j}{w_i}$$
$$= \frac{\gamma_{ij} + \beta_i \beta_j \log(E/P)}{w_i} + w_j$$

b. Theoretical demand restrictions

i. Adding-up

From (A-5),

i) $\sum_i w_i \eta_i = 1$

$\rightarrow \quad \sum_i w_i \left[1 + \frac{\beta_i}{w_i}\right] = \sum_i w_i + \sum_i \beta_i = 1$

$\rightarrow \quad$ Since $\sum_i w_i = 1$,

$$\rightarrow \qquad \sum_i \beta_i = 0 .$$

ii) $\sum_i w_i \varepsilon_{ij} + w_j = 0$

$$\rightarrow \qquad \sum_i w_i \varepsilon_{ij} + w_j$$

$$= \sum_i w_i \left[-\delta_{ij} + \frac{\gamma_{ij} - \beta_i \left[w_j - \beta_j \log(E/P) \right]}{w_i} \right] + w_j$$

$$= 0$$

where $\delta_{ij} = \begin{cases} 1 & \text{if} \quad i = j \\ 0 & \text{otherwise} \end{cases}$

$$\rightarrow \qquad -\sum_i \delta_{ij} w_i$$

$$+ \sum_i \gamma_{ij} - w_j \sum_i \beta_i + \beta_j \log(E/P) \sum_i \beta_i + w_j = 0$$

$$\rightarrow \qquad -w_j + \sum_i \gamma_{ij} + w_j = 0 \qquad \text{(Since } \sum_i \beta_i = 0 \text{)}$$

$$\rightarrow \qquad \sum_i \gamma_{ij} = 0$$

iii) Also given $\sum_i w_i = 1$, $\sum_i \alpha_i = 1$

ii. Homogeneity

From (A-7),

$$\sum_j \varepsilon_{ij} + \eta_i = 0$$

$$\rightarrow \qquad \sum_j \left[-\delta_{ij} + \frac{\gamma_{ij} - \beta_i \left[w_j - \beta_j \log(E/P) \right]}{w_i} \right] + 1 + \frac{\beta_i}{w_i} = 0$$

$$\rightarrow \qquad -1 + \frac{1}{w_i} \sum_j \gamma_{ij} - \frac{\beta_i}{w_i} \sum_j w_j$$

$$+ \frac{\beta_i \log(E/P)}{w_i} \sum_j \beta_j + 1 + \frac{\beta_i}{w_i} = 0$$

$$\rightarrow \qquad \frac{1}{w_i} \sum_j \gamma_{ij} + \frac{\beta_i \log(E/P)}{w_i} \sum_j \beta_j = 0$$

$$\rightarrow \qquad \sum_j \gamma_{ij} = 0 \qquad \text{and} \qquad \sum_j \beta_j = 0$$

iii. Symmetry

From (A-13),

$$\begin{aligned}
&\varepsilon_{ij}{}^{*} w_i = \varepsilon_{ji}{}^{*} w_j \\
\rightarrow \quad & \left[\frac{\gamma_{ij} - \beta_i \beta_j \log(E/P)}{w_i} + w_j \right] w_i \\
& = \left[\frac{\gamma_{ji} - \beta_j \beta_i \log(E/P)}{w_j} + w_i \right] w_j \\
\rightarrow \quad & \gamma_{ij} - \beta_i \beta_j \log(E/P) + w_i w_j \\
& = \gamma_{ji} - \beta_i \beta_j \log(E/P) + w_i w_j \\
\rightarrow \quad & \gamma_{ij} = \gamma_{ji}
\end{aligned}$$

4. LA/AIDS

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left(\frac{E}{P^*} \right),$$

where $\log P^* = \sum_k w_k \log p_k$ and assume $\dfrac{\partial \log P^*}{\partial \log p_j} = w_j$

$$\begin{aligned}
\rightarrow \quad & w_i = \frac{p_i q_i}{E} \\
\rightarrow \quad & \log w_i = \log p_i + \log q_i - \log E \\
\rightarrow \quad & \log q_i = \log w_i - \log p_i + \log E
\end{aligned}$$

a. Elasticities

- Total expenditure elasticities:

$$\eta_i = \frac{\partial \log q_i}{\partial \log E} = \frac{\partial \log w_i}{\partial \log E} + 1 = \frac{\beta_i}{w_i} + 1$$

- Uncompensated cross-price elasticities:

$$\begin{aligned}
\varepsilon_{ii} &= \frac{\partial \log q_i}{\partial \log p_i} = \frac{\partial \log w_i}{\partial \log p_i} - 1 = \frac{1}{w_i} \left[\gamma_{ii} - \beta_i \frac{\partial \log P^*}{\partial \log p_i} \right] - 1 \\
&= \frac{\gamma_{ii} - \beta_i w_i}{w_i} - 1
\end{aligned}$$

$$= \frac{\gamma_{ii}}{w_i} - \beta_i - 1$$

$$\varepsilon_{ij} = \frac{\partial \log q_i}{\partial \log p_j} = \frac{\partial \log w_i}{\partial \log p_j} = \frac{1}{w_i}\left[\gamma_{ij} - \beta_i \frac{\partial \log P^*}{\partial \log p_j}\right]$$
$$= \frac{\gamma_{ij} - \beta_i w_j}{w_i}$$

- Compensated cross-price elasticities:

$$\varepsilon_{ii}^{\ *} = \varepsilon_{ii} + \eta_i w_i = \frac{\gamma_{ii}}{w_i} - \beta_i - 1 + \left(1 + \frac{\beta_i}{w_i}\right) w_i$$
$$= \frac{\gamma_{ii}}{w_i} + w_i - 1$$

$$\varepsilon_{ij}^{\ *} = \varepsilon_{ij} + \eta_i w_j = \frac{\gamma_{ij} - \beta_i w_j}{w_i} + \left(1 + \frac{\beta_i}{w_i}\right) w_j$$
$$= \frac{\gamma_{ij}}{w_i} + w_j$$

b. Theoretical demand restrictions

i. Adding-up

From (A-5),

i) $\sum_i w_i \eta_i = 1$

$\rightarrow \quad \sum_i w_i \left[1 + \frac{\beta_i}{w_i}\right] = \sum_i w_i + \sum_i \beta_i = 1$

$\rightarrow \quad$ Since $\sum_i w_i = 1$

$\rightarrow \quad \sum_i \beta_i = 0$.

ii) $\sum_i w_i \varepsilon_{ij} + w_j = 0$

$\rightarrow \quad \sum_i w_i \varepsilon_{ij} + w_j = \sum_i w_i \left[-\delta_{ij} + \frac{\gamma_{ij} - \beta_i w_j}{w_i}\right] + w_j = 0$

$$\text{where} \quad \delta_{ij} = \begin{cases} 1 & \text{if} \quad i = j \\ 0 & \text{otherwise} \end{cases}$$

$$\rightarrow \quad -\sum_i \delta_{ij} w_i + \sum_i \gamma_{ij} - w_j \sum_i \beta_i + w_j = 0$$

$$\rightarrow \quad -w_j + \sum_i \gamma_{ij} + w_j = 0 \qquad (\text{Since } \sum_i \beta_i = 0)$$

$$\rightarrow \quad \sum_i \gamma_{ij} = 0$$

iii) Also given $\sum_i w_i = 1$, $\sum_i \alpha_i = 1$

ii. Homogeneity

From (A-7),

$$\sum_j \varepsilon_{ij} + \eta_i = 0$$

$$\rightarrow \quad \sum_j \left[-\delta_{ij} + \frac{\gamma_{ij} - \beta_i w_j}{w_i} \right] + 1 + \frac{\beta_i}{w_i} = 0$$

$$\rightarrow \quad -1 + \frac{1}{w_i} \sum_j \gamma_{ij} - \frac{\beta_i}{w_i} \sum_j w_j + 1 + \frac{\beta_i}{w_i} = 0$$

$$\rightarrow \quad \frac{1}{w_i} \sum_j \gamma_{ij} = 0$$

$$\rightarrow \quad \sum_j \gamma_{ij} = 0$$

iii. Symmetry

From (A-13),

$$\varepsilon_{ij}{}^* w_i = \varepsilon_{ji}{}^* w_j$$

$$\rightarrow \quad \left[\frac{\gamma_{ij}}{w_i} + w_j \right] w_i = \left[\frac{\gamma_{ji}}{w_j} + w_i \right] w_j$$

$$\rightarrow \quad \gamma_{ij} + w_i w_j = \gamma_{ji} + w_i w_j$$

$$\rightarrow \quad \gamma_{ij} = \gamma_{ji}$$

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