ECONOMIC ANALYSIS
PROPOSED RULE

ALLOW FRESH HASS AVOCADOS GROWN IN APPROVED ORCHARDS IN APPROVED MUNICIPALITIES IN MICHOACAN, MEXICO, TO BE IMPORTED INTO ALL STATES YEAR-ROUND
(APHIS DOCKET NO. 03-022-3)

U.S. Department of Agriculture
Animal and Plant Health Inspection Service

May 19, 2004

SUMMARY

This analysis addresses economic impacts of a proposed rule that would allow fresh Hass avocados from Mexico to be imported into all States of the United States throughout the year. The United States Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) is proposing this action at the request of the Government of Mexico. Economic effects of the rule are analyzed as required by Executive Order 12866. Possible impacts for small entities are considered in accordance with the Regulatory Flexibility Act.

Economic effects of allowing Hass avocados from Mexico to be imported into all States year-round are analyzed using a static, partial equilibrium model. The model has three demand regions: 31 northeastern and central States (and the District of Columbia) currently approved to receive Hass avocado imports from Mexico during the 6-month period, October 15-April 15 (Region A); 16 Pacific and southern States, excluding California and Florida, not approved to receive Hass avocados from Mexico (Region B); and California and Florida (Region C). Separation of California and Florida into a third region is based on their much higher per capita demand for Hass avocados compared to other States.

There are three supply regions in the model: California, Mexico, and Chile. Nearly all U.S. Hass avocado production takes place in California. Over 96 percent of all Hass avocado imports are supplied by Chile and Mexico. Two time periods are specified in the model, given the current six-month restriction on Hass avocado imports from Mexico: October 15-April 15 (Period 1); and April 16-October 14 (Period 2). Throughout the following discussion, "avocado" refers only to fresh Hass avocados unless otherwise indicated.

With respect to pest risks, a systems approach currently in place provides redundant safeguards against pest introduction. Risk mitigation measures include pest field surveys; orchard certification; and packinghouse, packaging, and shipping requirements. Since shipments into the conterminous United States began in 1997, cutting and inspection of over 10 million Mexican avocados has not revealed any quarantine pests.

The pest risk assessment for the proposed rule finds an overall low likelihood of quarantine pest introduction, concluding that:

- Fewer than 387 infested avocados will enter the United States each year, estimated with 95 percent confidence.
- Fewer than 49 avocados infested with stem weevil, seed weevils, and seed moth will enter avocado producing areas each year, estimated with 95 percent confidence.
- Fewer than 143 avocados infested with fruit flies will enter fruit fly susceptible areas each year, estimated with 95 percent confidence.
- Fewer than 3 avocados infested with stem weevil, seed weevils and seed moth will be discarded in avocado producing areas each year, estimated with 95 percent confidence.

- Fewer than 8 avocados infested with fruit flies will be discarded in fruit fly susceptible areas each year, estimated with 95 percent confidence.

- Based on the statistical models used to estimate sampling efficacy, it is slightly more likely that zero infested avocados will enter the United States than one infested avocado. APHIS cannot rule out the possibility that infested avocados may enter the country.

The proposed rule includes certain changes in the risk mitigations. In the approved orchards in Michoacán, Mexico, surveys for the quarantine pests of concern would be increased from annually to semiannually, given that the avocados would be allowed to be imported throughout the year. In the packinghouses, a sample of 300 avocados per consignment currently must be selected, cut, and inspected and found free from pests. APHIS is proposing to remove the specific sample size of 300 fruit and replace it with a requirement for a biometric sample at a rate determined by APHIS to be appropriate for the size of the particular consignment. Consignments of avocados would no longer need to be officially sealed before shipment, but rather would be required to be packed, at the packinghouse in Mexico, in insect-proof cartons or covered with insect-proof mesh or a plastic tarpaulin that must remain intact upon arrival of the avocados in the United States. Ports-of-entry and transit pathways would no longer be restricted, since access would be allowed to all States. Repackaging requirements specific to Mexican avocados after they enter the United States would be replaced by general repackaging requirements for imported plants and plant parts. Costs related to any of these changes are expected to be small and not significantly influence the supply of Mexican avocados. Costs associated with risk mitigation changes in Mexico would be borne by Mexican entities.

The Model

The analysis is based on a set of equations that describe, on the demand side, avocado consumption in the United States, and on the supply side, foreign and domestic avocado production for the U.S. market. Demand for avocados in the model is derived from a weakly separable utility function for a representative consumer. The utility function is assumed to contain two partitions of all goods purchased by consumers: avocados and everything else. In addition, avocados produced in each of the three supply regions are assumed to be heterogeneous products, based on observed wholesale price differentials. A nested constant elasticity of substitution (CES) utility function is used. The main advantage of this functional form is the minimal number of parameters needed to make the model operational. A major disadvantage of the CES utility function is that income elasticities can only equal 1.

On the supply side, a constant elasticity of transformation (CET) production possibility frontier is used to capture the option of producers to leave ripe avocados on the tree and shift their sale between time periods as relative prices change. Like the CES utility function, the main advantage of the CET function is that it is parsimonious in the parameters. Only a single, constant elasticity of transformation must be chosen in order to apply this functional form.

Initial quantities and prices used as the baseline for the model are averages for the two-year period, October 15, 2000 to October 15, 2002. Constant elasticities of substitution and transformation are specified, based on demand and supply elasticities derived from the literature, namely: a wholesale-level price elasticity of demand for California of -0.96, an aggregated wholesale-level price elasticity of demand of -0.67, and a price elasticity of supply for California of 0.35. The elasticities of substitution and transformation are then applied to the model's demand and supply equations to replicate the baseline quantities and prices, yielding shift parameter values. The equations are then resolved using different shift parameters to account for the greater access to U.S. markets afforded avocado imports from Mexico under the proposed rule. Resulting changes in prices and quantities provide the basis for approximating welfare impacts for avocado consumers and producers in the United States, and effects for small entities.

Shift parameters for avocados from Mexico have initial zero values in Regions B and C (Pacific and southern States) at all times and in Region A (northeastern and central States) during Period 2. Without adjusting these parameters, the model cannot show the effect on U.S. avocado demand of allowing Mexican avocados year-round access to all States. This raises the question of what this adjustment should be. Changes in the shift parameters can be thought of as changes in non-price influences on the relative demand for avocados. Even if avocados from the three supply regions were equal in price, demand for them would not be the same because of consumers' perceptions and preferences.

We assume that with removal of import restrictions, shift parameter values for avocados from Mexico that are initially zero can be set equal to the shift parameter values for Chilean avocados, by demand region and time period. In other words, consumers' preference for Mexican avocados would be the same as their preference for Chilean avocados. This adjustment rule may overstate this effect for Mexican avocados with respect to California avocados, and understate the effect with respect to Chilean avocados. Changes in demand for California avocados (and impacts for California producers) estimated by the model may therefore be larger than would be the case if newly available avocados from Mexico were to result in a decline in the shift parameter not only for California avocados, but for Chilean avocados as well.

Another basis for adjustment of the shift parameters would be to equate them to the initial parameter values for Region A during Period 1: approximately 0.39 for California, 0.14 for Chile, and 0.47 for Mexico. However, applying these shift parameters to Region A in Period 2 and to Regions B and C in both time periods would result in an even larger increase in Mexico's supply and decrease in the supply by California's producers than is shown by the analysis. Moreover, Region A during Period 1 is the demand region and time period of least importance to California's producers, whereas most of Mexico's worldwide avocado exports occur during the October 15 to April 15 time period.

We invite public comment on the basis by which we adjust the shift parameters for this analysis. We welcome suggestions of other possible adjustment rules.

In the model, California producer prices are FOB prices reported by the California Avocado Commission. Chilean and Mexican producer prices are CIF import values reported by USDA Foreign Agricultural Service. "Producer" prices refer in all cases to the FOB and CIF values.

Currently, Mexico is exporting to the United States a fraction of the avocados that could be exported from approved orchards and municipalities in the State of Michoacán. An estimated

479 million pounds of fresh avocados could be certified for export to the United States. During the baseline period, imports from Mexico totaled approximately 64.2 million pounds, or 13.4 percent of what potentially could be certified for export to the United States. It is apparent that Mexican producers could readily expand their level of exports to the United States at the current price level. Compared to an average wholesale price during the baseline period in the United States of $1.14 per pound, the average wholesale price in Mexico in 2001 was $0.46 per pound, and in 2002, $0.37 per pound. We assume in the model that the export supply of avocados from Mexico is perfectly elastic, and that the price Mexico's producers receive for their exports is constant (or fixed). We recognize that, in reality, prices in Mexico are not constant, and that this assumption results in a larger level of avocado imports from Mexico than if their demand were modeled as price-responsive. However, price changes are likely to be very small as long as there are large quantities of avocados that meet requirements for sale in the United States but are consumed domestically within Mexico or are exported elsewhere.

Effects on Supply and Demand

Impacts on quantities and prices are shown in table I. Overall, U.S. avocado consumption under the proposed rule would increase by 10.4 percent. Quantities supplied by California and Chile would decline by 9.5 percent and 8.9 percent, respectively, while imports from Mexico would increase to nearly 3.7 times their initial level, from 38.5 million pounds to over 141 million pounds.

Given producers' inelastic supply, the decline in price is of greater significance for California producers than is the decline in the quantity supplied. California's prices would fall by 15.4 percent at the wholesale level and by 25.6 percent at the producer level. Price impacts for avocados supplied by Chile would be much smaller, since their initial price is closer to that of avocados from Mexico.

Effects by demand region, supply region, and time period are provided by the model. Two-thirds of avocado imports from Mexico under the proposed rule would enter during Period 1. In Regions B and C during Period 1, avocados from Mexico would displace 30 percent and 23 percent of the avocados that had been supplied by California.

Because overall demand for avocados from California and Chile would decrease in both time periods, wholesale and producer prices for avocados from California and Chile also would decrease in both time periods. Imports from Mexico during Period 1 would comprise a larger share of total avocado consumption and therefore would exert greater downward pressure than during Period 2 on prices of avocados supplied by California and Chile.

Welfare Effects

Price and quantity changes described by the model translate into the welfare changes for U.S. avocado consumers and producers are shown in table II. For consumers, the concept of equivalent variation is used to quantify these changes. Equivalent variation (EV) refers to the additional amounts of income measured at initial equilibrium prices that would be equal to the price and quantity changes from removing the restrictions on the importation of avocados from Mexico.

Table I. Summary of Changes in Quantities and Prices[a]

	Initial Prices and Quantities	With Rule	Change	Percentage Change
	Million Pounds			
Quantity				
Total	537.643	593.785	+56.142	+10.4%
Supplied by:				
California	376.629	340.895	-35.734	-9.5%
Chile	122.564	111.715	-10.849	-8.9%
Mexico	38.450	141.174	+102.724	+267.2%
	Dollars per Pound			
Wholesale Price of Avocados Supplied by:				
California	$1.49	$1.26	-$0.23	-15.4%
Chile	$1.24	$1.16	-$0.08	-6.5%
Producer Price for:				
California	$0.90	$0.67	-$0.23	-25.6%
Chile	$0.52	$0.45	-$0.07	-13.5%

[a]Prices weighted by regional and time period quantities. Producer and wholesale prices for avocados from Mexico are assumed constant in the model.

Under the proposed rule, the decrease in California avocado prices due to producers' inelastic supply response would result in large gains in consumer utility. EV across all regions and time periods would total $115.3 million. Not surprisingly, consumers in Region A in Period 1 would gain the least, since this is the region already approved to receive avocados from Mexico. Consumer gains in Regions B and C would be similar for both time periods.

Welfare impacts for avocado producers in California and Chile are determined by computing changes in producer surplus based on their avocado factor endowment supply curves. A fall in producer prices will decrease the amount of factor endowment employed in avocado production. Given the decline in producer prices, California avocado producers would experience welfare losses equivalent to $84.5 million. Chile's suppliers would lose producer surplus equivalent to $8.5 million.

The net change in U.S. welfare is computed by subtracting the loss in producer surplus for California producers from the total EV. As shown in table II, the net welfare gain would be $30.8 million.

A sensitivity analysis was conducted of the changes in avocado supply and demand and changes in consumer and producer welfare, in recognition of the uncertainty surrounding parameters and exogenous variables such as the demand and supply elasticities. The results of the sensitivity analysis for the welfare effects are given in the mean and standard deviation columns in table II.

Relative to the baseline and mean values, the standard deviations for the EV values are small, suggesting that the parameters and exogenous variables used in the model are reasonable. The standard deviations for the changes in producer surplus are larger, implying a lower level of confidence in the precision of the results. In the sensitivity analysis, the loss in producer surplus for California producers ranged from $65.3 million to $114.2 million.

Table II. Welfare Gains and Losses

	Welfare Effect[a]	Mean[b]	Std Dev[c]
	Million Dollars		
Changes in Producer Surplus			
California	-$84.49	-$86.88	$16.45
Chile	-$8.46	-$9.23	$2.98
Equivalent Variation			
Period 1[d]			
Region A	$7.92	$8.31	$1.33
Region B	$24.36	$25.02	$2.19
Region C	$23.80	$24.57	$2.58
Period 2[e]			
Region A	$14.70	$14.92	$3.19
Region B	$22.06	$22.36	$4.25
Region C	$22.44	$22.80	$5.21
Net U.S. Welfare Change	$30.78	$31.10	$2.30

[a]The difference between baseline values and values with the proposed rule.
[b]Mean values of the sensitivity analysis distributions.
[c]Standard deviations of the sensitivity analysis distributions.
[d]October 15-April 15.
[e]April 16-October 14.

Effects for Small Entities

As a part of the rulemaking process, APHIS evaluates whether regulations are likely to have a significant economic impact on a substantial number of small entities. The Small Business Administration has set size criteria for small entities according to the categories of the North American Industrial Classification System. Entities that would be directly affected by the proposed rule are U.S. producers, handlers (firms engaged in postharvest activities), and importers of avocados.

APHIS is unable to assess effects of the proposed rule for small-entity avocado handlers and importers, since we are lacking information on the number of firms that would be affected, their size distributions, and degree to which their businesses depend on the avocado industry. In general, handlers operating in California could be expected to experience a decline in business, based on the results of the analysis. Negative effects could be at least partially cancelled by additional avocado business activities in Mexico in which U.S. handlers may be involved.

U.S. avocado importers as a group would gain from the increased volume of imports from Mexico, but gains for the industry would be tempered by reduced imports from Chile. We welcome information that would allow us to evaluate impacts of the proposed rule for affected handlers and importers that are small entities.

California's large and small avocado producers are expected to incur welfare losses as described. APHIS has been unable to obtain current information on the size distribution of affected avocado producers. For the purposes of our analysis, we rely on information provided in the 1997 Census of Agriculture on the size distribution of avocado farms. (Information from the 2002 Census of Agriculture is not yet available.)

An avocado farm is considered small if it has annual receipts of not more than $750,000. According to the 1997 Census of Agriculture, over 98 percent of avocado farms are small entities. The Census of Agriculture data include producers of all varieties of avocados. We assume Hass avocado production is distributed proportionately among the various farm sizes, that is, over 98 percent of the farms growing Hass avocados are small.

Expected impacts can be described in terms of decreases in gross revenue for California producers, as shown in table III. The model indicates that the overall decline in gross revenue would be 32.9 percent.

Table III. Annual Impact on Gross Revenue for California Avocado Producers

Initial gross revenue (Baseline)[a]	$339.38 million
Gross revenue with the proposed rule[a]	$227.83 million
Decrease in gross revenue incurred by large and small Hass avocado producers	$111.55 million
Decrease incurred by small-entity avocado producers[b]	$70.28 million
Decrease as a percentage of initial gross revenue[c]	32.9%

[a]Gross revenue values are based on the producer prices and demand quantities for avocados supplied by California, shown rounded in table I.
[b]Decreases in gross revenue are multiplied by 63 percent, the percentage of the total value produced by farms with less than 100 acres harvested in 1997. Hass avocado production is assumed to be proportionally distributed among farms of all sizes.
[c]The decrease in gross revenue is assumed to be proportionally spread across all producers.

In evaluating the expected impact for California's small-entity avocado producers, the large number of very small farms should be acknowledged. As indicated by the 1997 data, over one-half of the avocado farms that year harvested less than five acres. Average 1997 gross income for these farms was about $4,800. Clearly, farms of less than five acres could not be the principal source of income for their owners. Notwithstanding this large percentage of very small farms, table III indicates that California small-entity avocado farms could be seriously affected by the proposed rule. Generally, we assume regulations that entail compliance costs equal to a small business's profit margin—5 to 10 percent of annual sales—pose an impact that can be considered significant. Impacts simulated by this model would meet this criterion.

Alternatives

One alternative to the proposed rule would be to leave the regulations unchanged. In this case, access of Mexican avocados would continue to be restricted to the 31 States and the District of Columbia currently approved to receive avocados from Mexico between October 15 and April 15 (and Alaska year-round). Impacts for U.S. producers and consumers simulated for the proposed rule would not occur. In general, demand for avocados from all three supply regions would be expected to continue to expand due to growth in population and income. It is noted, however, that increases in avocado imports from Mexico in recent years (27.9 million pounds in 2001, 58.8 million pounds in 2002, 76.8 million pounds in 2003, as reported by World Trade Atlas) would indicate that suppliers of Mexican avocados also may be increasing their market share in the currently approved States.

Other alternatives to the proposed rule would be to increase access of Mexican avocados to the United States, but not to all States year-round. We would expect that any expansion of Mexico's access to the U.S. market other than that proposed, either regionally or by time period, would result in a lower level of additional avocado imports from Mexico and therefore smaller price and quantity impacts for California avocado producers. California producers' welfare losses would be less, as would welfare gains for consumers. Net welfare benefits of such alternatives would depend upon the relative magnitude of changes in U.S. producer and consumer surplus.

To illustrate the impacts of such an alternative, we consider effects of allowing access of Mexican avocados to all States except the avocado-producing States of California, Florida, and Hawaii. An analysis of expected impacts of this alternative, summarized here, is based on entry of Mexican avocados into California and Florida continuing to be prohibited. These two States produce over 99 percent of the Nation's avocados (all varieties). Hawaii's small production is largely for intrastate sale.

Quantity and price changes of allowing Mexican avocados to enter all States throughout the year, except California, Florida, and Hawaii, are shown in table IV. Under this alternative, avocado consumption would increase by 6.8 percent (compared to 10.4 percent under the proposed rule). Quantities supplied by California and Chile would decline by 5.6 percent and 5.8 percent, respectively (compared to 9.5 and 8.9 percent), while imports from Mexico would increase to 103 million pounds (compared to 141 million pounds), about 2½ times their initial level. California's prices would fall by 10.1 percent at the wholesale level (compared to 15.4 percent) and by 15.6 percent at the producer level (compared to 25.6 percent). Thus, all impacts are diminished in comparison to those that would result from the proposed rule.

Welfare effects for this alternative are shown in table V. Total equivalent variation across all regions and time periods would be $76.3 million, compared to $115.3 million under the proposed rule. California avocado producers would experience welfare losses of $52.4 million (compared to $84.5 million). The net gain in welfare for the United States would be $23.9 million (compared to $30.8 million).

Table IV. Alternative of Allowing Avocados from Mexico to be imported Year-round into All States, except California, Florida and Hawaii: Summary of Changes in Quantities and Prices[a]

	Initial Prices and Quantities[b]	With Rule[c]	Change	Percentage Change
	Million Pounds			
Quantity				
Total	537.643	574.296	+36.653	+6.8%
Supplied by:				
California	376.629	355.480	-21.149	-5.6%
Chile	122.564	115.511	-7.053	-5.8%
Mexico	38.450	103.305	+64.855	+168.7%
	Dollars per Pound			
Wholesale Price of Avocados Supplied by:				
California	$1.49	$1.34	-$0.15	-10.1%
Chile	$1.24	$1.19	-$0.05	-4.0%
Producer Price for:				
California	$0.90	$0.76	-$0.14	-15.6%
Chile	$0.52	$0.47	-$0.05	-9.6%

[a]Prices weighted by regional and time period quantities. Producer and wholesale prices for avocados from Mexico are assumed constant in the model.

As with the sensitivity analysis of impacts of the proposed rule, a sensitivity analysis for this alternative indicated small standard deviations for the EV values and larger ones for the producer surplus. The loss in producer surplus for California producers was found to range from $40.6 million to $71.2 million.

Expected impacts for California's small-entity avocado producers under this alternative, in terms of the decreases in gross revenue, are shown in table VI. The decline would be 20.5 percent, compared to a decline of nearly 33 percent under the proposed rule. California small-entity avocado farms could still be greatly affected under this alternative, but not as severely.

In sum, effects in terms of changes in prices, quantities, and welfare measures would be smaller than the impacts expected under the proposed rule. By excluding California, Florida, and Hawaii from the proposed increased access for Mexican avocados, California's producers would experience smaller welfare losses, but consumers' gains and net welfare gains would also be lower. The proposed rule allowing Mexican avocados to be imported into all States year-round is based on the pest risk assessment's conclusion of an overall low likelihood of quarantine pest introduction.

Table V. Alternative of Allowing Avocados from Mexico to be imported Year-round into All States, except California, Florida and Hawaii: Welfare Gains and Losses

	Welfare Effect[a]	Mean[b]	Std Dev[c]
	Million Dollars		
Changes in Producer Surplus			
California	-$52.39	-$54.11	$10.59
Chile	-$5.59	-$6.13	$2.05
Equivalent Variation			
Period 1[d]			
Region A	$3.99	$4.20	$0.76
Region B	$18.27	$18.64	$1.31
Region C	$12.36	$12.97	$2.28
Period 2[e]			
Region A	$10.89	$11.11	$1.87
Region B	$16.98	$17.28	$2.49
Region C	$13.79	$14.20	$3.47
Net U.S. Welfare Change	$23.89	$24.29	$1.27

[a]The difference between baseline values and values with the proposed rule.
[b]Mean values of the sensitivity analysis distributions.
[c]Standard deviations of the sensitivity analysis distributions.
[d]October 15-April 15.
[e]April 16-October 14.

Table VI. Alternative of Allowing Avocados from Mexico to be imported Year-round into All States, except California, Florida and Hawaii: Annual Impact on Gross Revenue for California Avocado Producers

Initial gross revenue (Baseline)	$338.97 million
Gross revenue under the alternative	$269.60 million
Decrease in gross revenue incurred by large and small Hass avocado producers	$69.37 million
Decrease incurred by small-entity avocado producers[a]	$43.70 million
Decrease as a percentage of initial gross revenue[b]	20.5%

[a]Decreases in gross revenue are multiplied by 63 percent, the percentage of the total value produced by farms with less than 100 acres harvested in 1997. Hass avocado production is assumed to be proportionally distributed among farms of all sizes.
[b]The decrease in gross revenue is assumed to be proportionally spread across all producers.

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ECONOMIC ANALYSIS
PROPOSED RULE

ALLOW FRESH HASS AVOCADOS GROWN IN APPROVED ORCHARDS IN APPROVED MUNICIPALITIES IN MICHOACAN, MEXICO, TO BE IMPORTED INTO ALL STATES YEAR-ROUND (APHIS DOCKET NO. 03-022-3)

May 19, 2004

1. Introduction

This analysis addresses economic impacts of a proposed rule that would allow fresh Hass avocados from Mexico to be imported into all States of the United States throughout the year.[1] At present, Hass avocados from Mexico may only be imported into some States, and only during part of the year. Economic effects of the rule are analyzed as required by Executive Order 12866. Possible impacts for small entities are considered in accordance with the Regulatory Flexibility Act.

The United States Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) is proposing this action at the request of the Government of Mexico.

In this Introduction, the approach taken in analyzing impacts is described. Section 2 sets forth the model used for the analysis, baseline data, and the model's calibration. Expected effects of the proposed rule on the supply and demand for Hass avocados, and a sensitivity analysis of these results, are presented in section 3. In section 4, welfare effects for U.S. Hass avocado producers and consumers are examined. Expected effects for small entities are described in section 5. Alternatives to the proposed rule are considered in section 6.

Until relatively recently, entry of Hass avocados from Mexico into the United States was prohibited due to phytosanitary risks. The blanket prohibition was partially lifted in 1993, when APHIS authorized their entry into one State, Alaska. Then in November 1997, fresh Hass avocados from Mexico were allowed entry into the conterminous United States for the first time. Entry was allowed into 19 northeastern States and the District of Columbia during a four-month period, November through February[2]. In 2001, the area approved for import was expanded by an additional 12 States, and the period of import was extended to six months, October 15 to April 15 (figure 1)[3]. The proposed rule would allow entry of fresh Hass avocados from Mexico into all States year-round.

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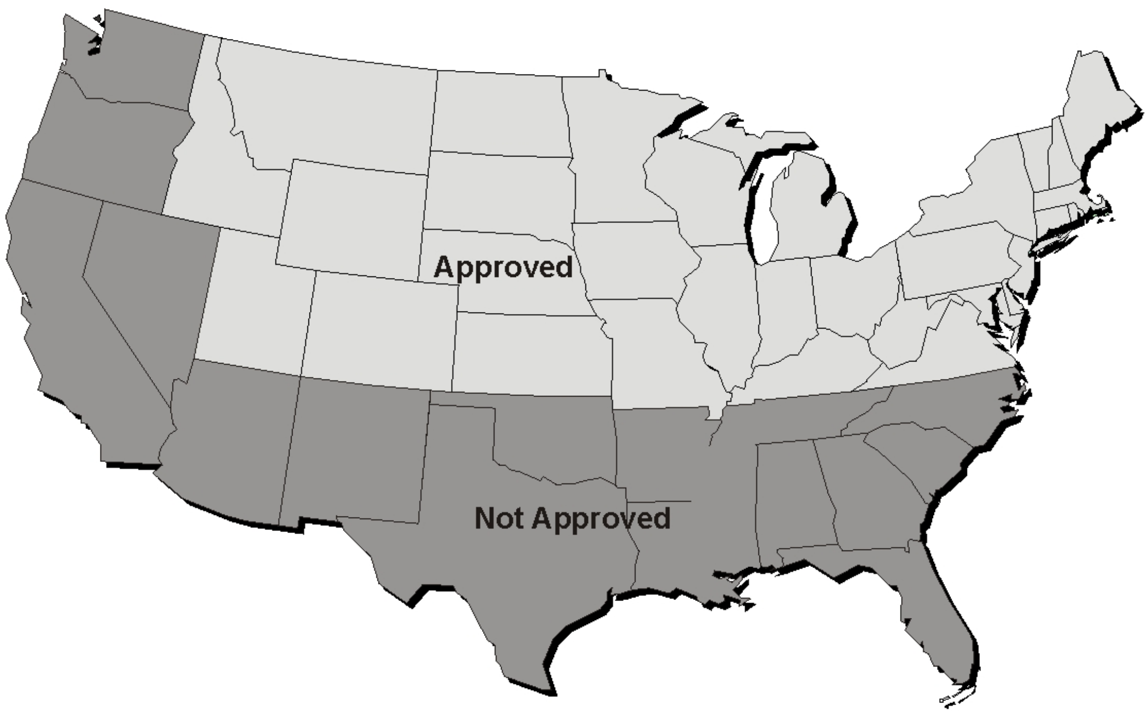
[1] The analysis is the result of collaboration of APHIS economists with Everett Peterson, Associate Professor, Department of Agricultural and Applied Economics, Virginia Polytechnic Institute and State University.
[2] The effective date of the final rule was March 7, 1997. The approved area included Connecticut, Delaware, District of Columbia, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin.
[3] The effective date of the final rule was November 1, 2001. The States added were Colorado, Idaho, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Utah, and Wyoming.

The impact of allowing Hass avocados from Mexico to be imported into all States year-round is analyzed using a static, partial equilibrium model. Initial quantities and prices used in the model are based on a two-year period, October 15, 2000 to October 15, 2002. The model's framework is summarized in table 1.

Figure 1. States Approved and Not Approved, as of November 2001, to Receive Fresh Hass Avocados from Mexico between October 15 and April 15



Note: Alaska is approved to receive Hass avocados from Mexico year-round. Hawaii is not approved to receive Hass avocados from Mexico.

The model has three demand regions: 31 northeastern and central States (and the District of Columbia) currently approved to receive Hass avocado imports from Mexico during the 6-month period, October 15-April 15 (Region A); 16 Pacific and southern States, excluding California and Florida, not approved to receive Hass avocados from Mexico (Region B); and California and Florida (Region C).[4] Separation of California and Florida into a third region is reasonable, given their much higher per capita demand for Hass avocados compared to other States. During the baseline period, per capita Hass avocado consumption in California and Florida is estimated to have been 4.2 pounds per year, compared to 1 pound and 2.2 pounds per year for Regions A and B, respectively.

[4] States not approved to receive Hass avocados from Mexico are Alabama, Arizona, Arkansas, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, Nevada, New Mexico, North Carolina, Oklahoma, Oregon, South Carolina, Tennessee, Texas, and Washington. As mentioned, Hass avocados from Mexico have been allowed to be imported year-round into Alaska since 1993.

Table 1. Model Framework

3 Demand Regions	• *Region A* States approved to receive Hass avocados from Mexico between October 15 and April 15 • *Region B* States not approved to receive Hass avocados from Mexico, excluding California and Florida • *Region C* California and Florida
3 Supply Regions	• California • Chile • Mexico
2 Time Periods	• *Period 1* October 15 to April 15 • *Period 2* April 16 to October 14

There are three supply regions in the model: California, Mexico, and Chile. Nearly all U.S. Hass avocado production takes place in California.[5] Over 96 percent of all Hass avocado imports are supplied by Chile and Mexico.[6]

Two time periods are specified in the model, given the current six-month restriction on Hass avocado imports from Mexico: October 15-April 15 (Period 1); and April 16-October 14 (Period 2).

Initial quantities and prices used as the baseline for the model are averages for the two-year period, October 15, 2000 to October 15, 2002. Briefly, constant elasticities of substitution and transformation are specified, based on demand and supply elasticities derived from the literature, namely: a wholesale-level price elasticity of demand for California of -0.96, an aggregated wholesale-level price elasticity of demand of -0.67, and a price elasticity of supply for California of 0.35. (Elasticities of substitution and transformation are explained, literature sources are identified, and the derivation of demand elasticities is described in section 2 and appendix 2.) The elasticities of substitution and transformation are then applied to the model's demand and supply equations to replicate the baseline quantities and prices, yielding shift parameter values. The equations are then resolved using different shift parameters to account for the greater access to U.S. markets afforded avocado imports from Mexico under the proposed rule. Resulting changes in prices and quantities provide the basis for approximating welfare impacts for Hass avocado consumers and producers in the United States, and effects for small entities.

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[5] Production of the Hass variety in Florida and Hawaii is negligible (Florida and Hawaii Agricultural Statistics Services). About 80 percent of California's avocado production is of the Hass variety (California Avocado Commission).

[6] The percentage is based on import data from the US Census Bureau, July 2001-April 2003. July 2001 was the first month in which Hass avocado imports were distinguished from imports of other avocado varieties.

With respect to pest risks, a systems approach currently in place provides redundant safeguards against pest introduction. Risk mitigation measures include pest field surveys; orchard certification; and packinghouse, packaging, and shipping requirements. Since shipments into the conterminous United States began in 1997, cutting and inspection of over 10 million Mexican avocados has not revealed any pests.

The pest risk assessment for the proposed rule finds an overall low likelihood of quarantine pest introduction, concluding that:

- Fewer than 387 infested avocados will enter the United States each year, estimated with 95 percent confidence.

- Fewer than 49 avocados infested with stem weevil, seed weevils, and seed moth will enter avocado producing areas each year, estimated with 95 percent confidence.

- Fewer than 143 avocados infested with fruit flies will enter fruit fly susceptible areas each year, estimated with 95 percent confidence.

- Fewer than 3 avocados infested with stem weevil, seed weevils and seed moth will be discarded in avocado producing areas each year, estimated with 95 percent confidence.

- Fewer than 8 avocados infested with fruit flies will be discarded in fruit fly susceptible areas each year, estimated with 95 percent confidence.

- Based on the statistical models used to estimate sampling efficacy, it is slightly more likely that zero infested avocados will enter the United States than one infested avocado. APHIS cannot rule out the possibility that infested avocados may enter the country.

The proposed rule includes certain changes in the risk mitigations. In the approved orchards in Michoacán, Mexico, surveys for the quarantine pests of concern would be increased from annually to semiannually, given that the avocados would be allowed to be imported throughout the year. In the packinghouses, a sample of 300 avocados per consignment currently must be selected, cut, and inspected and found free from pests. APHIS is proposing to remove the specific sample size of 300 fruit and replace it with a requirement for a biometric sample at a rate determined by APHIS to be appropriate for the size of the particular consignment. Consignments of avocados would no longer need to be officially sealed before shipment, but rather would be required to be packed, at the packinghouse in Mexico, in insect-proof cartons or covered with insect-proof mesh or a plastic tarpaulin that must remain intact upon arrival of the avocados in the United States. Ports-of-entry and transit pathways would no longer be restricted, since access would be allowed to all States. Repackaging requirements specific to Mexican avocados after they enter the United States would be replaced by general repackaging requirements for imported plants and plant parts. Costs related to any of these changes are expected to be small and not significantly influence the supply of Mexican avocados. Costs associated with risk mitigation changes in Mexico would be borne by Mexican entities.

2. The Model, Data, and Model Calibration

The Model

As mentioned in the Introduction, the analysis is based on a static, partial equilibrium model. The model has 34 endogenous variables, 28 exogenous variables, and 34 equations, as shown in appendix 1.

The 34 endogenous variables are (i) the quantities of avocados consumed in each demand region provided by each supply region during each time period, (ii) the wholesale price index in each demand region in each time period, (iii) producer prices in California and Chile in each time period, (iv) quantities of avocados supplied by California and Chile in each time period, and (v) the levels of factor endowment in California and Chile.

The 28 exogenous variables are (i) the populations in each demand region, (ii) per capita incomes in each demand region in each time period, (iii) marketing margins in each demand region for avocados provided by each supply region during each time period, and (iv) the producer price in Mexico (considered the same for both time periods).

The model and its calibration are described mathematically in appendix 2. In this and the following sections, "avocado" refers only to fresh Hass avocados unless otherwise indicated.

Demand. The demand for avocados is derived from a weakly separable utility function for a representative consumer.[7] The utility function is assumed to contain two partitions of all goods purchased by consumers: avocados and everything else. In addition, avocados produced in each of the three supply regions are assumed to be heterogeneous products. This assumption rests on observed wholesale price differentials in 14 cities, as described below in the discussion of the baseline data.

Figure 2 shows the assumed preference structure for a representative consumer. There are two different substitution possibilities in consumption. The parameter s_2 represents the elasticity of substitution between avocados from the different supply regions.[8] An increase in the price of California avocados, for example, relative to the prices of avocados from Mexico and Chile will lead the representative consumer to substitute away from the relatively more expensive California product to the relatively less expensive imports.[9] The parameter s_1 represents the elasticity of substitution between avocados from all supply regions and all other goods. An overall decrease in the relative price of avocados (represented by a price index) would lead to the

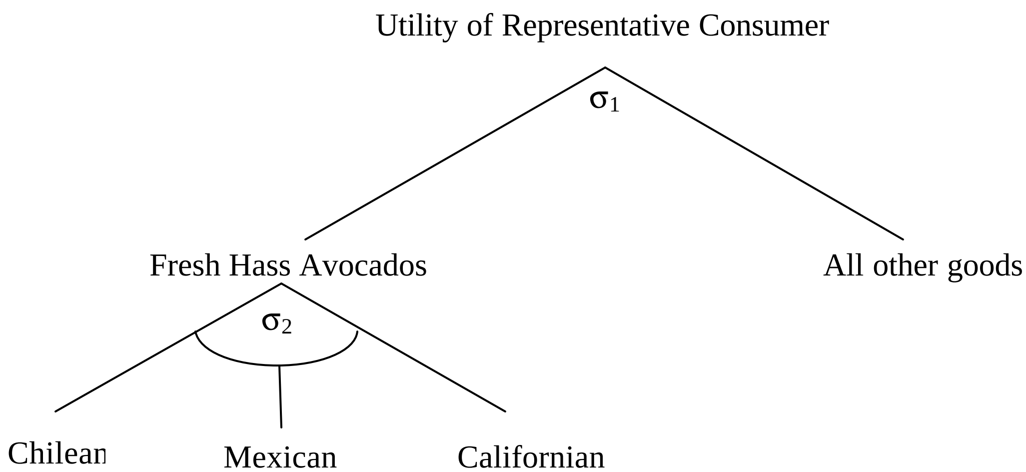
[7]Utility refers to the satisfaction gained from consuming some commodity. A basic assumption of the theory of household behavior is that households seek to maximize their total utility. The assumption of weak separability allows the demand for avocados to be specified as a function of avocado prices, an avocado price index, and total expenditure.

[8]Elasticity of substitution refers to the percentage change in relative demand for two goods (in this case, avocados from different supply regions), given a percentage change in their relative prices.

[9]In a homogeneous goods model, would equal infinity, that is, avocados from the different supply regions would be perfect substitutes.

representative consumer increasing his or her consumption of avocados from all regions.[10] Thus the value of the parameter s_1 will determine the magnitude of the own-price aggregate demand elasticity for avocados in the model. This determination is discussed in appendix 2.

Figure 2. Preference Structure for a Representative Consumer



A nested Constant Elasticity of Substitution (CES) utility function is used in the model.[11] The main advantage of this functional form is the minimal number of parameters needed to make the model operational: only values for s_1 and s_2 are required to be specified.[12] The main drawback to the CES functional form is that it is homothetic, which implies that all of the income elasticities of demand are equal to one.

Supply. Because ripe avocados may be left on the tree for many months before harvesting, it is possible for producers to shift avocado sales between time periods as relative prices change. A Constant Elasticity of Transformation (CET) production possibility frontier is used to capture this possibility.[13] Like the CES utility function, the main advantage of using a CET function is

[10] The price of all other goods is held constant in the partial equilibrium model, and any change in the avocado price index represents a change in relative prices.
[11] A constant elasticity of substitution means that, at all price levels, the percentage change in the relative demand for two goods due to a given percentage change in their relative prices is always the same.
[12] In a general model with *n* goods, ½(*n*)(*n* – 1) elasticities of substitution and (*n*-1) income elasticities of demand must be specified. For a model with four goods, this would imply six elasticities of substitution and three income elasticities. Because little empirical evidence exists for own-price, cross-price, and income elasticities of demand for avocados, using a more general demand specification would require more ad hoc parameter choices to be made.
[13] The elasticity of transformation is somewhat analogous to the elasticity of substitution. In this case, we have a frontier of all possible production possibilities, for a given factor endowment level. In equilibrium, the relative supply of two goods (or in our case, the relative supply of the same good in two time periods) is dependent on their relative producer prices. Elasticity of transformation refers to the percentage change in the relative supply of two goods (or groups of goods), given a percentage change in their relative prices. A constant elasticity of transformation means that, at all price levels, the percentage change in the relative supply of two goods due to a given percentage change in their relative prices is always the same.

that it is parsimonious in the parameters. Only a single, constant elasticity of transformation must be chosen in order to apply this functional form.

The "supply" of avocados refers to the quantity of avocados sold in the United States. Because the large majority of avocados produced in California are consumed in the United States, the supply of avocados from California is used to represent the total production of avocados in that region.[14] The supply of avocados by Chile and Mexico is an export supply since the U.S. market is only one of several destinations. In the model, avocados supplied by Chile should therefore be more price responsive than avocados supplied by California. This distinction is important when choosing the supply elasticity (aggregated across the two time periods) for Chile, and is discussed further with respect to the model's calibration.

Currently, Mexico is exporting to the United States a fraction of the avocados that could be exported from approved orchards and municipalities in the State of Michoacán. An estimated 479 million pounds of fresh avocados could be certified for export to the United States. During the baseline period, imports from Mexico totaled approximately 64.2 million pounds, or 13.4 percent of what potentially could be certified for export to the United States. It is apparent that Mexican producers could readily expand their level of exports to the United States at the current price level. Compared to an average wholesale price during the baseline period in the United States of $1.14 per pound, the average wholesale price in Mexico in 2001 was $0.46 per pound, and in 2002, $0.37 per pound. We assume in the model that the export supply of avocados from Mexico is perfectly elastic, and that the price Mexico's producers receive for their exports is constant (or fixed). We recognize that, in reality, prices in Mexico are not constant, and that this assumption results in a larger level of avocado imports from Mexico than if their demand were modeled as price-responsive. However, price changes are likely to be very small as long as there are large quantities of avocados that meet requirements for sale in the United States but are consumed domestically within Mexico or are exported elsewhere.

Baseline Data

To implement the empirical model requires specifying a set of prices and quantities that represents an initial equilibrium. These values, shown in appendix 3 table 2, constitute the baseline. All prices and quantities are averages from the two-year period, October 15, 2000 to October 15, 2002. The benefit of using a multi-year base time period is that it reduces the chance of choosing an unusual year. A two-year period is chosen versus a longer base period because of the increases in imports from Mexico and Chile in recent years.

Quantity data for California avocados, shown in appendix 3 table 1, are based on monthly shipment information provided by the Avocado Marketing Research and Information Center.[15] Quantities of avocado imported from Chile and Mexico are taken from U.S. Census Bureau

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[14] U.S. avocado exports (all varieties) in 2002 totaled about 23.15 million pounds (U.S. Census Bureau, converted from kilograms). About 95 percent of U.S. avocado exports (all varieties) are produced in California (California Avocado Commission, as reported by UC Davis). California production for the 2001/02 crop year was 399.7 million pounds (California Avocado Commission), yielding an export share of California's avocado production (all varieties) of 5.5 percent ([23.15 x .95] / 399.7 = 0.055).

[15] AMRIC was created by California state law in 1985 to provide the California avocado industry with daily inventory and shipment information to guide harvest/market strategies.

monthly data. Distribution among the demand regions is described in the notes to appendix 3 table 1.

Wholesale price data are based on prices reported in Wholesale Market Fruit Reports (various issues), by Market News Archive, USDA Agricultural Marketing Service. Wholesale avocado price data were available for Atlanta, Baltimore, Boston, Chicago, Dallas, Detroit, Los Angeles, Miami, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, and St. Louis. During the period October 2000 through September 2001, the average wholesale price for California avocados was $1.505 per pound, while the average prices for avocados from Mexico and Chile were $1.14 per pound and $1.222 per pound, respectively.

In the model, California producer prices are FOB prices reported by the California Avocado Commission. Chilean and Mexican producer prices are CIF import values reported by USDA Foreign Agricultural Service. In this and the following sections, and in the appendixes, "producer" prices refer in all cases to the FOB and CIF values.

Price margins are derived by subtracting the baseline producer prices from the baseline wholesale prices in appendix 3 table 2. For example, the margins in Region A in Period 1 are $0.6613 per pound for California avocados, $0.6614 per pound for Chilean avocados, and $0.5069 per pound for Mexican avocados. The dollar values per pound of all margins are assumed to remain constant in all model simulations.

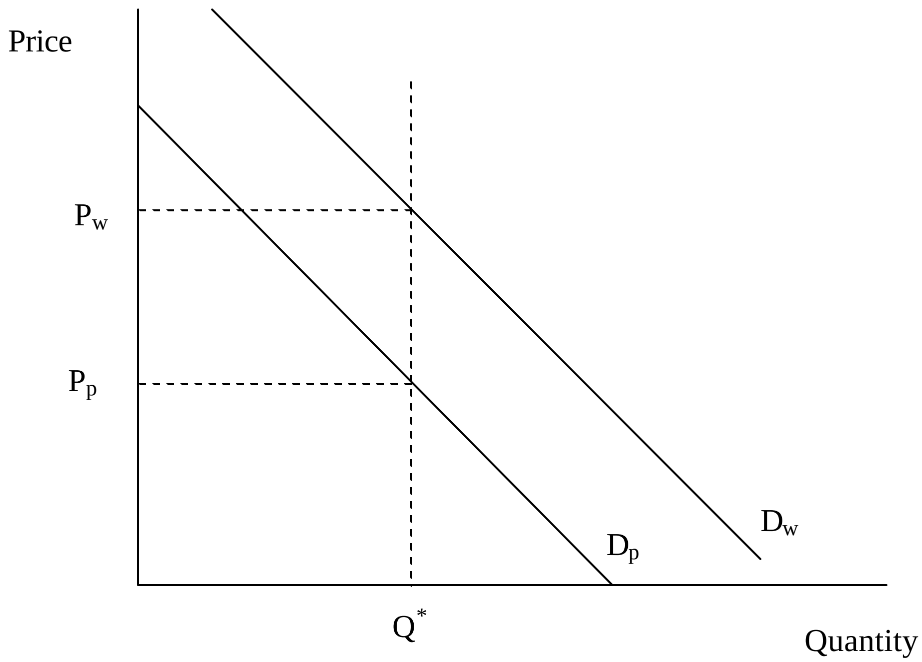
Model Calibration

Given the initial values of all prices and quantities in the model, values for parameters in appendix 1 are chosen such that the model can replicate the initial equilibrium while satisfying a set of supply and demand elasticities obtained from the literature. This subsection describes the calibration process.

Demand Elasticities. As mentioned, little existing empirical evidence exists on the magnitude of demand elasticities for avocados. Carman and Kraft (1998) estimated the inverse demand for California avocados using annual data from 1962 through 1995. They obtained a price flexibility of –1.33 when per capita consumption of California avocados equals 1.012 pounds and the producer price of avocados, deflated by the consumer price index (1982-84 base) equals 51.286 cents per pound. Because per capita consumption in our baseline data is higher, 1.336 pounds, and the real producer price is lower, 50.666 cents per pound, the flexibility estimate from Carman and Kraft must be adjusted. Using the parameter estimates reported in equation (10) in Carman and Kraft, per capita consumption of California avocados of 1.336 pounds and a real producer price of 50.666 cents per pound yields a price flexibility of –1.75, or a demand elasticity of –0.57.

Because the demand elasticity estimate derived from Carman and Kraft is for producer prices, it is adjusted to the wholesale level to be consistent with this model. In making this adjustment, we assume a fixed marketing margin, as illustrated in figure 3. The wholesale-level demand elasticity is obtained by multiplying the producer-level demand elasticity by the ratio of the wholesale price to the producer price. In the baseline data, the average ratio of wholesale price to producer price for California avocados across all markets and time periods is 1.679. Multiplying the implied own-price demand elasticity of –0.57 times 1.679 yields a wholesale-level demand elasticity of –0.96 for California avocados.

Figure 3. Relationship between Producer and Wholesale Demand with Fixed Marketing Margin



The wholesale-level demand elasticity for California avocados is used to determine an aggregate demand elasticity for avocados from all supply regions, which in turn is used to determine the appropriate value of s_1. This aggregated own-price demand elasticity equals the own-price elasticity for avocados supplied by California times California's share of the total supply. In the baseline data, the average quantity share of California avocados across all demand regions and time periods is 0.70. Thus, the implied aggregate demand elasticity is equal to –0.67.

The values of the own-price demand elasticity for California avocados and the aggregate own-price demand elasticity are used to determine values for s_1 and s_2 (appendix 2 table 1). Once these values of s_1 and s_2 have been determined, the shift parameters (a_{1ij}, a_{2ij}, b_{1i}, and b_{2i},) can be calculated (appendix 2 table 2). This involves solving a system of non-linear equations.

Aggregate Supply Elasticities. Calibration of the revenue functions for California and Chile depends on the assumed elasticity of transformation, that is, the ease with which avocado producers can shift their sales between the two time periods as relative producer prices between the periods change. The factor supply parameters used in the model are shown in appendix 2 table 3. In addition, aggregate supply elasticities for California and Chile determine how easily they can expand or contract total production as the avocado price index changes.

In their study, Carman and Kraft estimated that the supply elasticity for California avocados ranged from approximately 0.2 in the short run to a maximum of 1.3 in the long run. Romano (1998) used an aggregate supply elasticity of 0.35 for California avocados. For this analysis, an aggregate supply elasticity for California of 0.35 is used. For Chile, because the relevant supply elasticities are for export supply, not total supply, the aggregate supply elasticity must be adjusted based on the percentage of Chilean production that is exported. During the years 2000 to 2002, Chilean avocado producers exported 54.7 percent of their total production. Thus, the aggregate supply elasticity for Chile is equal to California's aggregate supply elasticity divided by 0.547.

Removal of Import Restrictions

To simulate the removal of import restrictions on Mexican avocados across time periods and demand regions requires that shift parameters a_{1ij} and a_{2ij} that are initially equal to zero be adjusted (appendix 2 table 2). Parameters for avocados from Mexico have initial zero values in Regions B and C (Pacific and southern States) at all times and in Region A (northeastern and central States) during Period 2. Without adjusting these parameters, the model cannot show the effect on U.S. avocado demand of allowing Mexican avocados year-round access to all States. This raises the issue of how to adjust the parameter values of a_{1ij} and a_{2ij}.

The effect of a change in the shift parameters can be thought of as a "varietal effect" that reflects non-price influences on the relative demand for avocados from each of the supply regions. Even if avocados from the three supply regions were equal in price, demand for them would not be the same because of consumers' perceptions and preferences.

Following the work of Venables (1987) on trade policy with differentiated products, we assume that with removal of import restrictions, shift parameter values for avocados from Mexico that are initially zero can be set equal to the shift parameter values for Chilean avocados, by demand region and time period. In other words, the varietal effect is assumed to be the same for avocados from either foreign source.

As an example of the adjustment, the initial shift parameter for avocados from Chile in Region A during Period 2 is equal to 0.1231055567 (appendix 2 table 2). Following removal of the restrictions, the shift parameter for avocados from Mexico is also set equal to 0.1231055567 for this demand region and time period, and the shift parameter for California avocados is decreased by the same amount to ensure that the a_{2ij}'s for Region A in Period 2 sum to one. This same procedure is followed for all demand regions and time periods in which the initial shift parameters for Mexican avocados are zero.

The Venables adjustment implies that if import restrictions on avocados from Mexico are removed, and if differences in price are ignored, consumers' preference for Mexican avocados would be the same as their preference for Chilean avocados. This adjustment rule may overstate these effects for Mexican avocados with respect to California avocados, and understate the effect with respect to Chilean avocados. Changes in demand for California avocados (and impacts for California producers) estimated by the model may therefore be larger than would be the case if newly available avocados from Mexico were to result in a decline in the shift parameter not only for California avocados, but for Chilean avocados as well.

Another basis for adjustment of the shift parameters would be to equate them to the initial parameter values for Region A during Period 1: approximately 0.39 for California, 0.14 for Chile, and 0.47 for Mexico. However, applying these shift parameters to Region A in Period 2 and to Regions B and C in both time periods would result in an even larger increase in Mexico's supply and decrease in the supply by California's producers than is shown by the analysis. Moreover, Region A during Period 1 is the demand region and time period of least importance to California's producers, whereas most of Mexico's worldwide avocado exports occur during the October 15 to April 15 time period.

We invite public comment on the basis by which we adjust the shift parameters for this analysis. We welcome suggestions of other possible adjustment rules.

3. Effects on Supply and Demand

A Classification of Effects

Removal of restrictions on Mexican avocado imports will increase their supply and affect the supply and demand for avocados from California and Chile. Impacts on demand can be decomposed into two price effects and the non-price varietal effect identified at the end of the previous section.

- Demand for avocados from each of the supply regions is affected by changes in relative prices. A decrease in the wholesale price of avocados from California or Chile relative to the price of avocados from Mexico, for example, will increase consumption of the former. This effect on demand of relative changes in wholesale prices is termed the substitution effect. The magnitude of this effect is determined by comparing per capita consumption for avocados in each demand region from each supply region at initial prices, using the changed shift parameters, to per capita consumption at the new prices, holding avocado expenditures constant.

- Similarly, a change in the aggregate price for avocados relative to a composite price for other goods affects their overall demand. A decrease in the price index for avocados from all three regions, for example, will lead to an increase in the demand for all avocados. They become relatively less expensive than other goods (whose price is held constant in the partial equilibrium model). We term this effect the expansion effect, to distinguish it from the first substitution effect and to highlight the impact on their overall demand of a change in the aggregate avocado price. The expansion effect is measured by comparing per capita consumption at initial prices and avocado expenditures, using the changed shift parameters, to per capita consumption at initial prices and the changed level of avocado expenditures.

- Lastly, there is the effect of changes in the utility function's shift parameters a_{1ij} and a_{2ij}. Together with the elasticities of substitution, these parameters determine the functional relationship between a representative consumer's utility and his/her consumption of avocados and all other goods (appendix 2 equation 1). As described previously, the effect of a change in the shift parameters can be thought of as a varietal effect that reflects non-price influences on the relative demand for avocados from each of the supply regions. Even if avocados from the three supply regions were equal in price, demand for them would not be the same because of consumers' perceptions and preferences. The term varietal effect is not used in a horticultural sense, but rather in reference to all non-price influences. A decrease in shift parameters for avocados from any of the three supply regions signifies a decrease in demand relative to the demand for avocados from the other regions, for reasons other than a change in price. The magnitude of this effect is measured by comparing per capita demand for avocados in each demand region from each supply region after the restrictions have been removed (holding prices and income constant), to their initial per capita demand.

Impacts

Mexican avocados imported for the first time into Region A during Period 2 and into Regions B and C throughout the year would affect the supply of avocados by California and Chile to all of the demand regions. Impacts on quantities and prices are shown in table 2. Overall, avocado consumption would increase by 10.4 percent. Quantities supplied by California and Chile would decline by 9.5 percent and 8.9 percent, respectively, while imports from Mexico would increase to nearly 3.7 times their initial level, from 38.5 million pounds to over 141 million pounds.

Given producers' inelastic supply, the decline in price is of greater significance for California producers than is the decline in the quantity supplied. California's prices would fall by 15.4 percent at the wholesale level and by 25.6 percent at the producer level. Price impacts for avocados supplied by Chile would be much smaller, since their initial price is closer to that of avocados from Mexico.

Effects by demand region, supply region, and time period are provided by the model. Two-thirds of avocado imports from Mexico under the proposed rule would enter during Period 1. In Regions B and C during Period 1, avocados from Mexico would displace 30 percent and 23 percent of the avocados that had been supplied by California.

Because overall demand for avocados from California and Chile would decrease in both time periods, wholesale and producer prices for avocados from California and Chile also would decrease in both time periods. Imports from Mexico during Period 1 would comprise a larger share of total avocado consumption and therefore would exert greater downward pressure than during Period 2 on prices of avocados supplied by California and Chile.

To better understand the changes in demand, they are decomposed in table 4 into the effects identified at the beginning of this section. There are two general results of the analysis. First, because the price of California avocados would decrease relative to the price of Mexican avocados, there would be a positive substitution effect for California avocados and a negative substitution effect for Mexican avocados. Second, because the aggregate demand for avocados is price inelastic, the expansion effect would be negative for all avocados across all regions and time periods. In calculating the expansion effect, price is held constant at its initial level, and expenditure on avocados is allowed to change. The fall in price is greater than the increase in quantity, due to the inelastic demand, so avocado expenditure declines. Because price is constant, the decline in expenditure is reflected in a lower quantity consumed and a negative expansion effect.

For Region A in Period 1, the consumption of avocados from California would increase while the consumption of avocados from Mexico would decrease (the consumption of avocados from Chile would remain largely unchanged). This shift is mainly due to a large decline in the wholesale price of avocados from California, relative to the wholesale price of Mexican avocados. In this region during Period 2, the varietal effects for California and Mexico would outweigh the substitution effects, leading to a decrease in the consumption of California avocados when Mexican avocados are no longer restricted.

For Regions B and C, the largest varietal effects would occur during Period 1, when imports are largest: In Region B, an increase of 35.3 million pounds for avocados from Mexico, and decreases of 25.3 million pounds and 3.5 million pounds for avocados from California and Chile; in Region C, an increase of 33.3 million pounds for avocados from Mexico, and decreases of 25.6 million pounds and 2.9 million pounds for avocados from California and Chile.

Table 2. Summary of Changes in Quantities and Prices[a]

	Initial Prices and Quantities	With Rule	Change	Percentage Change
	Million Pounds			
Quantity				
Total	537.643	593.785	+56.142	+10.4%
Supplied by:				
California	376.629	340.895	-35.734	-9.5%
Chile	122.564	111.715	-10.849	-8.9%
Mexico	38.450	141.174	+102.724	+267.2%
	Dollars per Pound			
Wholesale Price of Avocados Supplied by:				
California	$1.49	$1.26	-$0.23	-15.4%
Chile	$1.24	$1.16	-$0.08	-6.5%
Producer Price for:				
California	$0.90	$0.67	-$0.23	-25.6%
Chile	$0.52	$0.45	-$0.07	-13.5%

[a]Prices weighted by regional and time period quantities. Producer and wholesale prices for avocados from Mexico are assumed constant in the model.

Table 3. Simulation Results

	Initial Prices and Quantities[a]	With Rule[b]	Mean[c]	Std Dev[d]
<u>Quantity Demand</u>		Million Pounds		
Time Period 1[e]				
Region A				
California	18.227	25.572	25.897	1.140
Chile	10.201	10.358	10.459	0.258
Mexico	38.450	34.180	34.022	0.639
Region B				
California	52.283	37.012	37.438	1.558
Chile	30.859	27.036	27.245	0.473
Mexico	0.000	30.876	30.729	0.729
Region C				
California	57.613	44.525	45.063	2.000
Chile	33.839	30.359	30.608	0.554
Mexico	0.000	28.542	28.372	0.728
Time Period 2[f]				
Region A				
California	62.629	58.909	59.084	1.933
Chile	12.015	11.078	11.124	0.125
Mexico	0.000	11.933	11.927	0.442
Region B				
California	86.854	78.402	78.626	2.536
Chile	16.701	15.182	15.236	0.138
Mexico	0.000	20.733	20.736	0.863
Region C				
California	99.023	96.474	96.753	3.086
Chile	18.950	17.702	17.790	0.275
Mexico	0.000	14.910	14.896	0.594
California Production	376.629	340.895	342.860	12.199
Imports from Chile	122.564	111.715	112.480	1.813
Imports from Mexico	38.450	141.174	140.682	3.996
<u>Producer Price</u>		Dollars per Pound		
Time Period 1				
California	$0.878	$0.549	$0.538	$0.045
Chile	$0.534	$0.453	$0.445	$0.023
Time Period 2				
California	$0.913	$0.723	$0.721	$0.049
Chile	$0.500	$0.441	$0.438	$0.030

Table 3. Continued

	Initial Prices and Quantities[a]	With Rule[b]	Mean[c]	Std Dev[d]
Wholesale Price		Dollars per Pound		
Time Period 1[e]				
Region A				
California	$1.539	$1.210	$1.199	$0.045
Chile	$1.196	$1.115	$1.107	$0.023
Mexico	$1.140			
Region B				
California	$1.565	$1.236	$1.225	$0.045
Chile	$1.303	$1.222	$1.214	$0.023
Mexico	$1.140			
Region C				
California	$1.465	$1.137	$1.126	$0.045
Chile	$1.184	$1.103	$1.095	$0.023
Mexico	$1.140			
Time Period 2[f]				
Region A				
California	$1.466	$1.276	$1.274	$0.049
Chile	$1.244	$1.185	$1.182	$0.030
Mexico	$1.140			
Region B				
California	$1.539	$1.349	$1.347	$0.049
Chile	$1.402	$1.343	$1.340	$0.030
Mexico	$1.140			
Region C				
California	$1.441	$1.252	$1.249	$0.049
Chile	$1.100	$1.041	$1.038	$0.030
Mexico	$1.140			

[a]Baseline, as shown in appendix 3 table 2.
[b]Effects of the rule on quantities and prices (simulation results).
[c]Mean values of the sensitivity analysis distributions.
[d]Standard deviations of the sensitivity analysis distributions.
[e]October 15-April 15.
[f]April 16-October 14.

Table 4. Decomposition of the Demand Changes by Demand Region, Supply Region and Time Period

Demand Region/Supply Region	
Time Period 1[a]	Million Pounds
Region A, California	
Varietal effect	0.000
Substitution effect	7.913
Expansion effect	-0.566
Total	7.347
Region A, Chile	
Varietal effect	0.000
Substitution effect	0.474
Expansion effect	-0.317
Total	0.156
Region A, Mexico	
Varietal effect	0.000
Substitution effect	-3.074
Expansion effect	-1.195
Total	-4.269
Region B, California	
Varietal effect	-25.257
Substitution effect	10.936
Expansion effect	-0.950
Total	-15.270
Region B, Chile	
Varietal effect	-3.507
Substitution effect	0.645
Expansion effect	-0.962
Total	-3.824
Region B, Mexico	
Varietal effect	35.279
Substitution effect	-3.164
Expansion effect	-1.240
Total	30.876

Table 4. Continued

Demand Region/Supply Region	
Time Period 1	Million Pounds
Region C, California	
Varietal effect	-25.561
Substitution effect	6.904
Expansion effect	-16.628
Total	-35.286
Region C, Chile	
Varietal effect	-2.888
Substitution effect	0.330
Expansion effect	-16.057
Total	-18.615
Region C, Mexico	
Varietal effect	33.283
Substitution effect	-1.703
Expansion effect	-17.267
Total	14.312
Time Period 2[b]	
Region A, California	
Varietal effect	-10.974
Substitution effect	9.051
Expansion effect	-1.796
Total	-3.719
Region A, Chile	
Varietal effect	-0.487
Substitution effect	-0.050
Expansion effect	-0.401
Total	-0.937
Region A, Mexico	
Varietal effect	13.616
Substitution effect	-1.209
Expansion effect	-0.474
Total	11.933

Table 4. Continued

Demand Region/Supply Region	
Time Period 2	Million Pounds
Region B, California	
Varietal effect	-18.015
Substitution effect	11.743
Expansion effect	-2.179
Total	-8.452
Region B, Chile	
Varietal effect	-0.924
Substitution effect	-0.095
Expansion effect	-0.500
Total	-1.519
Region B, Mexico	
Varietal effect	23.375
Substitution effect	-1.902
Expansion effect	-0.740
Total	20.733
Region C, California	
Varietal effect	-14.081
Substitution effect	11.513
Expansion effect	-20.804
Total	-23.372
Region C, Chile	
Varietal effect	-0.593
Substitution effect	0.020
Expansion effect	-4.496
Total	-5.069
Region C, Mexico	
Varietal effect	17.164
Substitution effect	-1.269
Expansion effect	-4.204
Total	11.691

[a]October 15-April 15.
[b]April 16-October 14.

Sensitivity Analysis

A sensitivity analysis was conducted that considers alternative values for the elasticities of substitution and transformation (s_1, s_2, and b) and California's aggregate supply elasticity (h_A) in recognition of the uncertainty surrounding these parameters and exogenous variable. The approach used to vary them in the sensitivity analysis is described in appendix 4. Because no information is available about their distributions, uniform distributions were assumed, as shown in table 5.[16]

Table 5. Uniform Distributions Used in the Sensitivity Analysis

	Minimum	Mean	Maximum
s_1[a]	0.60	0.68	0.77
s_2	1.68	1.90	2.16
b	1.00	1.50	2.00
h_A	0.05	0.35	0.65

[a]The values of s_1 and s_2 depend on the estimated coefficient on the quantity of Californian avocado production in equation (10) in Carman and Kraft. The mean value of this coefficient is -0.53. A range of +/- three standard deviations is assumed (for example, +/-0.08 for s_1). The price flexibility at the producer level is computed as:

$$flex = r*1.336*50.666^{0.23},$$

where r is the value of the estimated coefficient (-0.53 in the base case). Taking the reciprocal of this expression and multiplying by 1.679 yields the own-price demand elasticity at the wholesale level, as explained in section 2. The aggregate demand elasticity for avocados is obtained by multiplying the wholesale level elasticity by 0.7. Once the values of these two elasticities have been obtained, the values of s_1 and s_2 can then be computed as described in appendix 2.

The results of the sensitivity analysis are given in the mean and standard deviation columns in table 3. Relative to the baseline and mean values, the standard deviations are small for all of the reported endogenous variables. These results indicate that the simulation results vary little for the given range of the parameters and exogenous variable used in modeling impacts of removing the restrictions on avocado imports from Mexico.

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[16] For a uniform random variable on the interval (a,b), $m = (a + b)/2$ and $s^2 = (b - a)^2/12$. In order to assure substitutability in demand, the value of s_2 must exceed the value of s_1. Thus the range of s_2 utilized in the sensitivity analysis is chosen to always exceed the value of s_1.

4. Welfare Effects

Removing restrictions on Mexican avocado imports will affect both consumers and producers. For consumers, the concept of equivalent variation is used to quantify these changes. Equivalent variation (EV) refers to the additional amounts of income measured at initial equilibrium prices that would be equal to the price and quantity changes from removing the restrictions on the importation of avocados from Mexico.

The EV for each demand region and time period is determined, as described in appendix 5, and the results are presented in table 6. Under the proposed rule, the decrease in California avocado prices due to producers' inelastic supply response (0.35) would result in large gains in consumer utility. EV across all regions and time periods would total $115.3 million. Not surprisingly, consumers in Region A in Period 1 would gain the least, since this is the region already approved to receive avocados from Mexico. Consumer gains in Regions B and C would be similar for both time periods.

The welfare impacts for avocado producers in California and Chile are determined by computing the change in producer surplus based on their avocado factor endowment supply curves.[17] As shown in figure 4, a decrease in the producer price index will decrease the amount of factor endowment employed in avocado production. The reduction in producer surplus is given by the sum of the areas in rectangle A and triangle B.

Given the decline in producer prices, California avocado producers would experience welfare losses equivalent to $84.5 million. Chile's suppliers would lose producer surplus equivalent to $8.5 million. The net change in U.S. welfare is computed by subtracting the loss in producer surplus for California producers from the total EV. As shown in table 6, the net welfare gain would be $30.8 million.

The mean and standard deviation columns in table 6 show the results of a sensitivity analysis of the welfare changes. As with the sensitivity analysis of the quantity and price changes in table 3, the standard deviations for the EV values are small. The standard deviations for the changes in producer surplus are larger, however, implying greater variability. In the sensitivity analysis, the loss in producer surplus for California producers ranged from $65.3 million to $114.2 million.

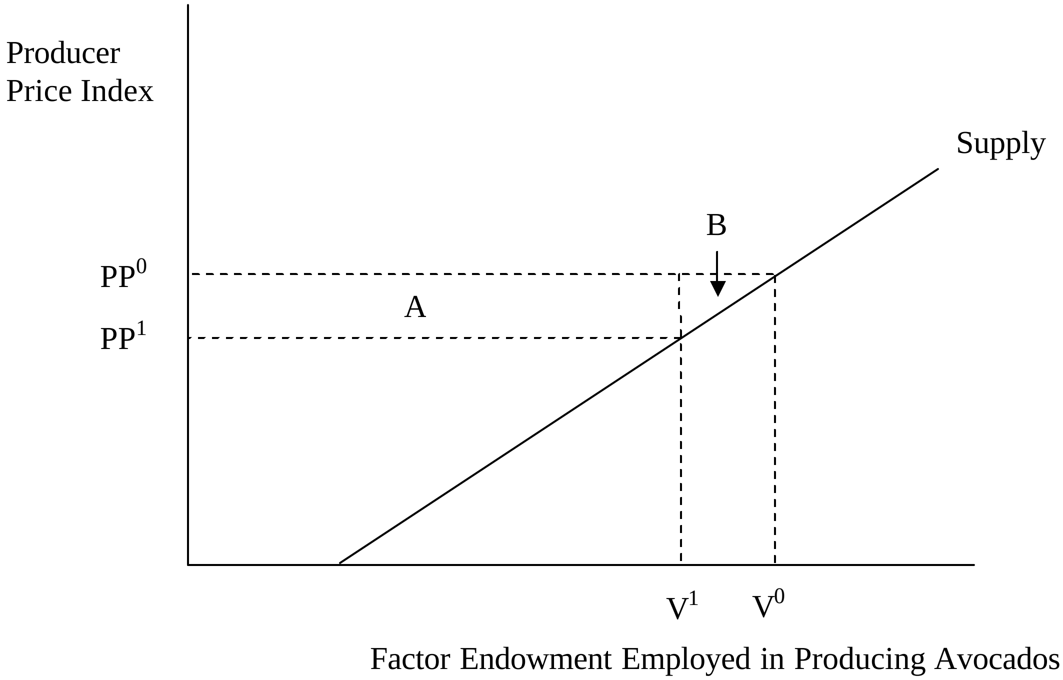
[17] The supply of the avocado endowment factor is used because it determines the overall level of avocado production in a given region. Also, by definition, producer surplus is based on the concept of a specific factor of production.

Table 6. Welfare Gains and Losses

	Welfare Effect[a]	Mean[b]	Std Dev[c]
	Million Dollars		
Changes in Producer Surplus			
California	-$84.49	-$86.88	$16.45
Chile	-$8.46	-$9.23	$2.98
Equivalent Variation			
Period 1[d]			
Region A	$7.92	$8.31	$1.33
Region B	$24.36	$25.02	$2.19
Region C	$23.80	$24.57	$2.58
Period 2[e]			
Region A	$14.70	$14.92	$3.19
Region B	$22.06	$22.36	$4.25
Region C	$22.44	$22.80	$5.21
Net U.S. Welfare Change	$30.78	$31.10	$2.30

[a]The difference between baseline values and values with the proposed rule.
[b]Mean values of the sensitivity analysis distributions.
[c]Standard deviations of the sensitivity analysis distributions.
[d]October 15-April 15.
[e]April 16-October 14.

Figure 4. Producer Surplus Loss from a Price Decrease for Avocado Producers in California and Chile



5. Effects for Small Entities

As a part of the rulemaking process, APHIS evaluates whether regulations are likely to have a significant economic impact on a substantial number of small entities.[18] The Small Business Administration has set size criteria for small entities according to the categories of the North American Industrial Classification System. Entities that would be directly affected by the proposed rule are U.S. producers, handlers (firms engaged in postharvest activities), and importers of avocados. We have insufficient information to evaluate impacts for handlers and importers. California's large and small avocado producers are expected to incur welfare losses as described in section 4, due to the increased access of avocados imported from Mexico.

Handlers and Importers

APHIS is unable to assess effects of the proposed rule for small-entity avocado handlers and importers, since we are lacking information on the number of firms that would be affected, their size distributions, and degree to which their businesses depend on the avocado industry. Avocado handlers are considered small businesses if their annual receipts are not more than $5 million.[19] Firms that import avocados are small if they have 100 or fewer employees.[20] We welcome information that would allow us to evaluate impacts of the proposed rule for affected handlers and importers that are small entities.

In general, handlers operating in California could be expected to experience a decline in business, based on the results of the analysis. Negative effects could be at least partially cancelled by additional avocado business activities in Mexico in which U.S. handlers may be involved. U.S. avocado importers as a group would gain from the increased volume of imports from Mexico, but gains for the industry would be tempered by reduced imports from Chile.

Producers

APHIS has been unable to obtain information on the size distribution of affected avocado producers. For the purposes of our analysis, we rely on information provided in the 1997 Census of Agriculture on the size distribution of avocado farms. (Information from the 2002 Census of Agriculture is not yet available.) Expected impacts are described in terms of decreases in gross revenue for California producers.

Table 7 presents information on California avocado producers from the 1992 and 1997 Censuses of Agriculture. During the five-year period between the censuses, the number of avocado farms decreased by 16 percent, but the distribution by farm size of avocado production and income did not change appreciably. We assume a similar size distribution characterizes the industry today.

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[18] "Guide to the Regulatory Flexibility Act." Small Business Administration, Office of Advocacy, Washington, DC, May 1996.
[19] North American Industry Classification System (NAICS) code 115114, Postharvest Crop Activities (except Cotton Ginning).
[20] NAICS code 442480, Fresh Fruit and Vegetable Wholesalers. The wholesale sector comprises two types of wholesalers: those that sell goods on their own account and those that arrange sales and purchases for others for a commission or fee. Importers are included in both cases.

In 1997, the category for the largest farms, those with 100 or more acres harvested, included only 96 out of a total of 5,036 farms in 1997 (less than 2 percent).

Table 7. California avocado farms and sales, categorized by number of acres harvested, 1992 and 1997

Acres Harvested	Farms	Pounds Harvested	Crop Value	Percent of Farms	Cumulative Percentage	Average Number of Pounds Harvested per Farm	Average Income from Sales per Farm
1997							
0.1 to 0.9	579	634,676	$568,683	11.5%	11.5%	1,096	$982
1.0 to 4.9	2,291	14,698,903	$13,170,516	45.5%	57.0%	6,416	$5,749
5.0 to 14.9	1,224	41,043,490	$36,775,802	24.3%	81.3%	33,532	$30,046
15.0 to 24.9	421	37,444,332	$33,550,884	8.4%	89.7%	88,941	$79,693
25.0 to 49.9	298	50,530,849	$45,276,669	5.9%	95.6%	169,567	$151,935
50.0 to 99.9	127	43,532,067	$39,005,618	2.5%	98.1%	342,772	$307,131
100 or more	96	110,646,247	$99,141,289	1.9%	100.0%	1,152,565	$1,032,722
Total	5,036	298,530,564	$267,489,461	100.0%		59,279	$53,115
1992							
0.1 to 0.9	608	595,408	$369,419	10.2%	10.2%	979	$608
1.0 to 4.9	2,895	15,862,901	$9,842,075	48.5%	58.6%	5,479	$3,400
5.0 to 14.9	1,462	40,456,122	$25,100,843	24.5%	83.1%	27,672	$17,169
15.0 to 24.9	473	35,977,576	$22,322,146	7.9%	91.0%	76,063	$47,193
25.0 to 49.9	320	48,191,503	$29,900,229	5.4%	96.4%	150,598	$93,438
50.0 to 99.9	119	38,325,726	$23,779,047	2.0%	98.4%	322,065	$199,824
100 or more	96	116,054,555	$72,005,595	1.6%	100.0%	1,208,902	$750,058
Total	5,973	295,463,791	$183,319,353	100.0%		49,467	$30,691

Sources: USDA NASS, 1992 and 1997 Census of Agriculture, Volume 1, Part 5, Chapter 1, Table 43. Values of production Based on California Avocado Commission data. Same unit values used for all farms: 1992, 62.045 cents per pound; 1997, 89.602 cents per pound.

An avocado farm is considered small if it has annual receipts of not more than $750,000.[21] As shown in the last column of table 7, producers with fewer than 100 acres harvested were small entities, on average, according to this criterion. Thus, over 98 percent of avocado farms in 1997 were small entities. The Census of Agriculture data include producers of all varieties of avocados. We assume Hass avocado production is distributed proportionately among the various farm sizes, that is, over 98 percent of the farms growing Hass avocados are small.

Table 8 shows the reduction in gross revenue for California producers that would occur under the proposed rule. The model indicates that the overall decline in gross revenue would be 32.9 percent.

[21]NAICS code 111339, Other Non-citrus Fruit Farming.

Table 8. Annual Impact on Gross Revenue for California Avocado Producers

Initial gross revenue (Baseline)[a]	$339.38 million
Gross revenue with the proposed rule[a]	$227.83 million
Decrease in gross revenue incurred by large and small Hass avocado producers	$111.55 million
Decrease incurred by small-entity avocado producers[b]	$70.28 million
Decrease as a percentage of initial gross revenue[c]	32.9%

[a]Gross revenue values are based on the producer prices and demand quantities for avocados supplied by California, shown in table 3.
[b]Decreases in gross revenue are multiplied by 63 percent, the percentage of the total value produced by farms with less than 100 acres harvested in 1997. Hass avocado production is assumed to be proportionally distributed among farms of all sizes.
[c]The decrease in gross revenue is assumed to be proportionally spread across all producers.

The gross revenue declines are attributable to decreases in price more so than decreases in quantity (table 9). Also, price and quantity decreases in Period 1, when impacts of avocado imports from Mexico are larger, are much greater than those in Period 2, the main season for California producers.

In evaluating the expected impact for California's small-entity avocado producers, the large number of very small farms should be acknowledged. As indicated by the 1997 data, over one-half of the avocado farms that year harvested less than five acres. Average 1997 gross income for these farms was about $4,800.[22] Clearly, farms of less than five acres could not be the principal source of income for their owners. Notwithstanding this large percentage of very small farms, table 8 indicates that California small-entity avocado farms could be seriously affected by the proposed rule.

Table 9. Percentage Changes in California Avocado Producer Prices and in Quantities of Avocados that would be Supplied by California

	Price	Quantity
Period 1	-37.5%	-16.4%
Period 2	-20.8%	-5.9%

[22] From table 5: ($568,683 + $13,170,516)/(579 + 2,291) = $4,787.

Generally, we assume regulations that entail compliance costs equal to a small business's profit margin—5 to 10 percent of annual sales—pose an impact that can be considered significant (Verkuil 1982). Impacts simulated by this model would meet this criterion.

6. Alternatives

One alternative to the proposed rule would be to leave the regulations unchanged. In this case, access of Mexican avocados would continue to be restricted to the 31 States and the District of Columbia currently approved to receive avocados from Mexico between October 15 and April 15 (and Alaska year-round). Impacts for U.S. producers and consumers simulated for the proposed rule would not occur. In general, demand for avocados from all three supply regions would be expected to continue to expand due to growth in population and income. It is noted, however, that increases in avocado imports from Mexico in recent years (27.9 million pounds in 2001, 58.8 million pounds in 2002, 76.8 million pounds in 2003, as reported by World Trade Atlas) would indicate that suppliers of Mexican avocados also may be increasing their market share in the approved States.

Other alternatives to the proposed rule would be to increase access of Mexican avocados to the United States, but not to all States year-round. We would expect that any expansion of Mexico's access to the U.S. market other than that proposed, either regionally or by time period, would result in a lower level of additional avocado imports from Mexico and therefore smaller price and quantity impacts for California avocado producers. California producers' welfare losses would be less, as would welfare gains for consumers. Net welfare benefits of such alternatives would depend upon the relative magnitude of changes in U.S. producer and consumer surplus.

To illustrate the impacts of such an alternative, we consider effects of allowing access of Mexican avocados to all States except the avocado-producing States of California, Florida, and Hawaii. An analysis of expected impacts of this alternative, summarized here, is based on entry of Mexican avocados into California and Florida continuing to be prohibited. These two States produce over 99 percent of the Nation's avocados (all varieties). Hawaii's small production is largely for intrastate sale.

Quantity and price changes of allowing Mexican avocados to enter all States throughout the year, except California, Florida, and Hawaii, are shown in table 10. Under this alternative, avocado consumption would increase by 6.8 percent (compared to 10.4 percent under the proposed rule). Quantities supplied by California and Chile would decline by 5.6 percent and 5.8 percent, respectively (compared to 9.5 and 8.9 percent), while imports from Mexico would increase to 103 million pounds (compared to 141 million pounds), about 2½ times their initial level. California's prices would fall by 10.1 percent at the wholesale level (compared to 15.4 percent) and by 15.6 percent at the producer level (compared to 25.6 percent). Thus, all impacts are diminished in comparison to those that would result from the proposed rule.

Table 10. Alternative of Allowing Avocados from Mexico to be imported Year-round into All States, except California, Florida and Hawaii: Summary of Changes in Quantities and Prices[a]

	Initial Prices and Quantities[b]	With Rule[c]	Change	Percentage Change
	Million Pounds			
Quantity				
Total	537.643	574.296	+36.653	+6.8%
Supplied by:				
California	376.629	355.480	-21.149	-5.6%
Chile	122.564	115.511	-7.053	-5.8%
Mexico	38.450	103.305	+64.855	+168.7%
	Dollars per Pound			
Wholesale Price of Avocados Supplied by:				
California	$1.49	$1.34	-$0.15	-10.1%
Chile	$1.24	$1.19	-$0.05	-4.0%
Producer Price for:				
California	$0.90	$0.76	-$0.14	-15.6%
Chile	$0.52	$0.47	-$0.05	-9.6%

[a]Prices weighted by regional and time period quantities. Producer and wholesale prices for avocados from Mexico are assumed constant in the model.

Welfare effects for this alternative are shown in table 11. Total equivalent variation across all regions and time periods would be $76.3 million, compared to $115.3 million under the proposed rule. California avocado producers would experience welfare losses of $52.4 million (compared to $84.5 million). The net gain in welfare for the United States would be $23.9 million (compared to $30.8 million).

As with the sensitivity analysis of impacts of the proposed rule, a sensitivity analysis for this alternative indicated small standard deviations for the EV values and larger ones for the producer surplus. The loss in producer surplus for California producers was found to range from $40.6 million to $71.2 million.

Table 11. Alternative of Allowing Avocados from Mexico to be imported Year-round into All States, except California, Florida and Hawaii: Welfare Gains and Losses

	Welfare Effect[a]	Mean[b]	Std Dev[c]
	Million Dollars		
Changes in Producer Surplus			
California	-$52.39	-$54.11	$10.59
Chile	-$5.59	-$6.13	$2.05
Equivalent Variation			
Period 1[d]			
Region A	$3.99	$4.20	$0.76
Region B	$18.27	$18.64	$1.31
Region C	$12.36	$12.97	$2.28
Period 2[e]			
Region A	$10.89	$11.11	$1.87
Region B	$16.98	$17.28	$2.49
Region C	$13.79	$14.20	$3.47
Net U.S. Welfare Change	$23.89	$24.29	$1.27

[a]The difference between baseline values and values with the proposed rule.
[b]Mean values of the sensitivity analysis distributions.
[c]Standard deviations of the sensitivity analysis distributions.
[d]October 15-April 15.
[e]April 16-October 14.

Expected impacts for California's small-entity avocado producers under this alternative, in terms of decreases in gross revenue, are shown in table 12. The decline would be 20.5 percent, compared to a decline of nearly 33 percent under the proposed rule. California small-entity avocado farms could still be greatly affected under this alternative, but not as severely.

Table 12. Alternative of Allowing Avocados from Mexico to be imported Year-round into All States, except California, Florida and Hawaii: Annual Impact on Gross Revenue for California Avocado Producers

Initial gross revenue (Baseline)	$338.97 million
Gross revenue under the alternative	$269.60 million
Decrease in gross revenue incurred by large and small Hass avocado producers	$69.37 million
Decrease incurred by small-entity avocado producers[a]	$43.70 million
Decrease as a percentage of initial gross revenue[b]	20.5%

[a]Decreases in gross revenue are multiplied by 63 percent, the percentage of the total value produced by farms with less than 100 acres harvested in 1997. Hass avocado production is assumed to be proportionally distributed among farms of all sizes.
[b]The decrease in gross revenue is assumed to be proportionally spread across all producers.

In sum, effects in terms of changes in prices, quantities, and welfare measures would be smaller than the impacts expected under the proposed rule. By excluding California, Florida, and Hawaii from the proposed increased access for Mexican avocados, California's producers would experience smaller welfare losses, but consumers' gains and net welfare gains would also be lower. The proposed rule allowing Mexican avocados to be imported into all States year-round is based on the pest risk assessment's conclusion of an overall low likelihood of quarantine pest introduction.

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Appendix 1. Model Variables and Equations

Endogenous Variables

$x1_{ij}, x2_{ij}, PI_{1i}, PI_{2i}, p_{1r}, p_{2r}, y_{1r}, y_{2r}, V_r; \quad \forall i = newc, cafl, rous; \forall j = cal, ch, mex; \forall r = cal, ch$

Exogenous Variables

$pop_i, I_{1i}, I_{2i}, m_{1ij}, m_{2ij}, p_{1,mex}, p_{2,mex}; \quad \forall i = newc, cafl, rous; \forall j = cal, ch, mex$

Variable Definitions

$x1_{ij}, x2_{ij}$ Quantity of avocado from supply region *j* consumed in demand region *i* in time periods 1 and 2

PI_{1i}, PI_{2i} Avocado price index in demand region *i* in time periods 1 and 2

p_{1j}, p_{2j} Producer price of avocados in supply region *j* in time periods 1 and 2

y_{1r}, y_{2r} Supply of avocados from region *r* in time periods 1 and 2

V_r Avocado factor endowment utilized in supply region *r*

pop_i Population in demand region *i*

I_{1i}, I_{2i} Per capita income in demand region *i* in time periods 1 and 2

m_{1ij}, m_{2ij} Fixed marketing margin for avocados from supply region *j* in demand region *i* in time periods 1 and 2

Consumer Demand

Time Period 1[a]

$$x1_{ij} = pop_i \left\{ \frac{b_{1i} a_{1ij} \left(p_{1j} + m_{1ij} \right)^{-s_2} PI_{1i}^{(s_2 - s_1)} I_{1i}}{b_{1i} PI_{1i}^{(1-s_1)} + \left(1 - b_{1i}\right)} \right\}, \quad \forall i = newc, cafl, rous^c; \forall j = cal, ch, mex^d$$

Time Period 2[b]

$$x2_{ij} = pop_i \left\{ \frac{b_{2i} a_{2ij} \left(p_{2j} + m_{2ij} \right)^{-s_2} PI_{2i}^{(s_2 - s_1)} I_{2i}}{b_{2i} PI_{2i}^{(1-s_1)} + \left(1 - b_{2i}\right)} \right\}, \quad \forall i = newc, cafl, rous; \forall j = cal, ch, mex$$

Demand Price Indices

Time Period 1

$$PI_{1i} = \left\{ \sum_j a_{1ij} \left(p_{1j} + m_{1ij} \right)^{(1-s_2)} \right\}^{\frac{1}{(1-s_2)}} \quad \forall i = newc, cafl, rous$$

Time Period 2

$$PI_{2i} = \left\{ \sum_j a_{2ij} \left(p_{2j} + m_{2ij} \right)^{(1-s_2)} \right\}^{\frac{1}{(1-s_2)}} \quad \forall i = newc, cafl, rous$$

Conditional Avocado Supply

Time Period 1

$$y_{1r} = d_r\, p_{1r}^{b_r - 1} \left\{ d_r\, p_{1r}^{b_r} + (1 - d_r)\, p_{2r}^{b_r} \right\}^{\frac{1}{b_r} - 1} V_r, \quad \forall r = cal, ch$$

Time Period 2

$$y_{2r} = (1 - d_r)\, p_{2r}^{b_r - 1} \left\{ d_r\, p_{1r}^{b_r} + (1 - d_r)\, p_{2r}^{b_r} \right\}^{\frac{1}{b_r} - 1} V_r, \quad \forall r = cal, ch$$

Supply of Avocado Factor Endowment

$$V_r = c_r + d_r \left\{ d_r\, p_{1r}^{b_r} + (1 - d_r)\, p_{2r}^{b_r} \right\}^{\frac{1}{b_r}}, \quad \forall r = cal, ch$$

Market Clearing Conditions

Time Period 1

$$y_{1r} = \sum_i x1_{ir}, \quad \forall r = cal, ch$$

Time Period 2

$$y_{2r} = \sum_i x2_{ir}, \quad \forall r = cal, ch$$

Mexican Producer Price

$$p_{1,mex} = p_{2,mex} = \overline{p}$$

[a]Time period 1: October 15 to April 15.

[b]Time period 2: April 16 to October 14.

[c]Demand regions: *newc (Region A)*, CO, CT, DE, DC, IA, ID, IL, IN, KS, KY, ME, MD, MA, MI, MN, MT, MO, NE, NH, NJ, NY, ND, PA, OH, RI, SD, UT, VT, VA, WV, WI, WY; *rous (Region B)*, AL, AZ, AR, GA, HI, LA, MS, NV, NM, NC, OK, OR, SC, TN, TX, WA; *cafl (Region C)*, CA and FL

[d]Supply regions: *cal*, California; *ch*, Chile; *mex*, Mexico.

Appendix 2. A Mathematical Description of the Model and Its Calibration

Demand

To represent the preference structure mathematically, a nested Constant Elasticity of Substitution utility function is used. This functional form is commonly used in empirical models concerning international trade issues. The utility function, uncompensated demand, and price index functions for the nested CES used in this model are defined as:

$$U_i = \left\{ b_i^{\frac{1}{s_1}} \left(\sum_j a_{ij}^{\frac{1}{s_2}} x_{ij}^{\frac{s_2-1}{s_2}} \right)^{\frac{s_2(s_1-1)}{s_1(s_2-1)}} + (1-b_i)^{\frac{1}{s_1}} XE_i^{\frac{s_1-1}{s_1}} \right\}^{\frac{s_1}{s_1-1}}, \sum_j a_j = 1, \qquad (1)$$

$$x_{ij} = \frac{b_i a_{ij} \left(p_{ij} + m_{ij} \right)^{-s_2} PI_i^{(s_2-s_1)} I_i}{b_i PI_i^{(1-s_1)} + (1-b_i) PE_i^{(1-s_1)}}, \text{ and} \qquad (2)$$

$$PI_i = \left\{ \sum_j a_{ij} \left(p_{ij} + m_{ij} \right)^{(1-s_2)} \right\}^{\frac{1}{(1-s_2)}}, \qquad (3)$$

where x_{ij} is the quantity of avocados from the jth supply region consumed in the ith demand region, XE_i is the aggregate quantity of all other goods consumed in the ith demand region, p_{ij} is the producer price of avocados from the jth producer region in the ith demand region, m_{ij} is the fixed marketing margin for avocados from the jth producer region in the ith demand region, PI_i is the avocado price index in demand region i, I_i is per capita income in demand region i, PE_i is the aggregate price of the composite "all other goods" category in demand region i, and b_i and a_{ij} are shift parameters.[23] Note that the time subscripts have been suppressed to simplify the notation.

Supply

Assuming that avocado producers maximize revenues, subject to a Constant Elasticity of Transformation production possibility frontier, a CET revenue function may be derived and is defined as:

$$R_j(p,V) = \left\{ d_j p_{1j}^{b_j} + (1-d_j) p_{2j}^{b_j} \right\}^{\frac{1}{b_j}} V_j, \qquad (4)$$

where R_j is the total revenue in the jth producer region across both time periods, p_{1j} and p_{2j} are the producer prices of avocado in the jth region in Periods 1 and 2 respectively, and V_j is the level of factor endowment used in avocado production in the jth region. Note that the level of V_j

[23] The values of the shift parameters a_{ij} and b_i are chosen such that the empirical model replicates an observed initial equilibrium.

determines the position of the production possibility frontier in output space and thus the position of the revenue function in price space. As more factors of production flow into the avocado industry in a given supply region, more avocados can be produced in both time periods and the production possibility frontier shifts out.

The conditional avocado supply function for each time period is derived by taking the first derivative of the CET revenue function with respect to the producer price for that time period.

$$\frac{\partial R_j}{\partial p_{1j}} = y_{1j}^c = d_j p_{1j}^{b_j - 1} \left\{ d_j p_{1j}^{b_j} + \left(1 - d_j\right) p_{2j}^{b_j} \right\}^{\frac{1}{b_j} - 1} V_j \text{ and} \qquad (5)$$

$$\frac{\partial R_j}{\partial p_{2j}} = y_{2j}^c = \left(1 - d_j\right) p_{2j}^{b_j - 1} \left\{ d_j p_{1j}^{b_j} + \left(1 - d_j\right) p_{2j}^{b_j} \right\}^{\frac{1}{b_j} - 1} V_j, \qquad (6)$$

where y_{1j}^c and y_{2j}^c are the conditional supply of avocados in Periods 1 and 2 from the jth region, V_j is the level of avocado factor endowment in the jth region, d_j is a shift parameter, and b_j is a parameter that determines the elasticity of transformation. These supply functions are considered "conditional" because the level of factor endowment is held constant.

However, the level of avocado factor endowment in each region is a function of the overall producer price level, holding production costs constant. An increase in the overall avocado producer price will encourage expanded production, which will require an increase in the amount of the avocado factor endowment employed. The level of V_j employed in the jth region is assumed to be a linear function of the avocado producer price index:

$$V_j = c_j + d_j PP_j, \qquad (7)$$

where PP_j is the avocado producer price index in the jth region, and c_j and d_j are parameters. The producer price index for a CET revenue function is defined as:

$$PP_j = \left\{ d_j p_{1j}^{b_j} + \left(1 - d_j\right) p_{2j}^{b_j} \right\}^{\frac{1}{b_j}}. \qquad (8)$$

Thus, the producer price index is a function of prices in both time periods. Note that the aggregate supply response in each region is determined by the responsiveness in equation (7) to a change in the producer price index.

Model Equations

Appendix 1 provides a list of all of the equations in the model. In addition to the equations discussed above, there are two additional equations that ensure the avocado market is in equilibrium, or "clears" in each time period. Note that the since the demand equations are for a representative consumer, they are multiplied by population to obtain the total amount of avocados consumed in each time period. Also, because the aggregate price of "all other goods" is held constant (due to partial equilibrium assumption), its value is arbitrarily set equal to one.

This choice does not affect the model results. Choosing a different value for PE_i would rescale the calibrated value of the b_i parameter.

Model Calibration

We use the inverse demand for California avocados estimated by Carman and Kraft (1998) to determine demand elasticities at the producer level, as described in section 2. We define the wholesale own-price demand elasticity (e_w) and the producer level own-price elasticity (e_p) as:

$$e_w = \frac{\partial Q}{\partial p_w}\frac{p_w}{Q} \text{ and } e_p = \frac{\partial Q}{\partial p_p}\frac{p_p}{Q},$$

where p_w is the wholesale price, p_p is the producer price, and Q is the common quantity level. If the marketing margin is constant, then the slope of the wholesale (D_w) and the derived producer level (D_p) demand functions are the same. Then the relationship between these two elasticities can be expressed as:

$$e_w = e_p \frac{Q}{p_p}\frac{p_w}{Q} = e_p \frac{p_w}{p_p}.$$

Because the aggregate demand curve may be thought of as the horizontal summation of the individual demand curves for avocados from the supply regions, at a constant price the aggregate own-price demand elasticity will be smaller in absolute terms than the individual own-price demand elasticities due to a larger quantity. Assuming that the slopes of the aggregate demand curve and the demand curve for California avocados are equal, then the relationship between the aggregate (e_A) and California (e_{cal}) own-price demand elasticity is:

$$e_A = e_{cal}\frac{Q_{cal}}{Q_A},$$

where Q_{cal} is the quantity of California avocados and Q_A is the aggregate or total quantity of avocados sold.

Based on the nested CES demand structure (figure 2 in section 2), the formulas for the own-price Allen partial elasticities of substitution (AEOS) are (Keller 1980):

$$s_{AA} = -s_1\left(s_A^{-1} - 1\right), \text{ and} \quad (9)$$

$$s_{cal,cal} = -\left[s_2\left(s_{cal}^{-1} - s_A^{-1}\right) + s_1\left(s_A^{-1} - 1\right)\right], \quad (10)$$

where s_{AA} is the aggregate own-price AEOS, s_A is the budget share of avocados, $s_{cal,cal}$ is the own-price AEOS for California avocados, and s_{cal} is the budget share of California avocados.

Using equation (9), the elasticity form of the Slutsky decomposition, and the homotheticity of the CES utility function, one can determine the value of s_1:

$$e_A = s_A\left(s_{AA} - h_A\right) = s_A\left[-s_1\left(s_A^{-1} - 1\right) - 1\right] = -s_1 + s_A\left(s_1 - 1\right), \text{ thus}$$

$$s_1 = \frac{e_A + s_A}{s_A - 1}. \qquad (11)$$

Once the value of s_1 has been determined, then substituting into equation (10) and using the Slutsky decomposition:

$$e_{cal} = s_{cal}\left\{-\left[s_2\left(s_{cal}^{-1} - s_A^{-1}\right) + s_1\left(s_A^{-1} - 1\right)\right] - 1\right\}.$$

Solving for s_2 yields:

$$s_2 = \frac{s_A\left\{e_{cal} + s_{cal}\left[1 + s_1\left(s_A^{-1} - 1\right)\right]\right\}}{s_{cal} - s_A}. \qquad (12)$$

Because the flexibility estimate from Carman and Kraft is based on annual, national data, the budget shares in equations (11) and (12) are averages across both time periods and the three demand regions in the baseline data. The calibrated values of s_1 and s_2 are reported in appendix 2 table 1, along with the implied uncompensated demand elasticities for avocados from the three supply regions in the three demand regions and two time periods.[24] Note that avocados from Mexico are only available in Region A during Period 1.

The income elasticities from a CES utility function are all equal to one. This raises the question of whether this is a valid assumption. Carmen and Kraft estimated that the producer price flexibility with respect to income equaled 2.77 when evaluated at the mean of their sample. Using this information, along with estimated own-price flexibility, it is possible to determine the implied producer level income elasticity for California avocados. Using the own-price flexibility and the mean price ($0.51286 per pound) and quantity (1.012 pounds per capita), the slope of the inverse demand function, using the definition of the price flexibility, is equal to:

$$\frac{\partial p}{\partial Q} = -1.33\frac{0.51286}{1.012} = -0.674.$$

The slope of the demand function is then the reciprocal of this value, or –1.484. Next, using the price flexibility with respect to income, a one percent increase in per capita income will increase

[24] The cross-price AEOS between avocados by producer region, which are all equal by definition of the CES function, are calculated based on the following formula from Keller: $s_{ij} = s_2 s_A^{-1} - s_1\left(s_A^{-1} - 1\right)$.

Appendix 2 Table 1. Calibrated Values of s_1 and s_2 and Implied Price Elasticity of Demand Values

Elasticities of Substitution	s_1	s_2	
	0.67	1.90	
Base Demand Elasticities		Supply Region	
Region A, Period 1	*California*	*Chile*	*Mexico*
California	-1.49	0.18	0.64
Chile	0.41	-1.72	0.64
Mexico	0.41	0.18	-1.26
Region A, Period 2	*California*	*Chile*	
California	-0.84	0.17	
Chile	1.06	-1.73	
Region B, Period 1	*California*	*Chile*	
California	-1.08	0.41	
Chile	0.82	-1.49	
Region B, Period 2	*California*	*Chile*	
California	-0.85	0.18	
Chile	1.05	-1.72	
Region C, Period 1	*California*	*Chile*	
California	-1.07	0.40	
Chile	0.83	-1.50	
Region C, Period 2	*California*	*Chile*	
California	-0.83	0.16	
Chile	1.07	-1.74	

the producer price of California avocados by 2.77 percent, or an increase of $0.01421 when evaluated at the sample means. Because by definition, the income elasticity is computed holding price constant, the effect of a change in income on the quantity demanded is computed by using the slope of the demand function and a price decrease of $0.01421. This yields an increase in per capita consumption of 0.021 pounds, or a 2.1 percent increase in the mean value. Thus, the implied producer level income elasticity from Carman and Kraft is 2.1, and CES income elasticities equal to one appear to be conservative in comparison.

For the parameters a_{1ij} and a_{2ij}, a system of r conditional demand equations, where r equals the number of avocado from each producer region consumed in each demand region in each time period, is solved. (Only r equations need to be solved since the requirement that the a_{ij}'s must sum to one in each demand region and time period is imposed.) These equations are conditional because expenditures on all avocados are held constant. For each demand region and time period, the following system of equations is solved to determine the values of a_{1ij} and a_{2ij}:

$$\frac{x_{ir}}{pop_i} = \frac{a_{ir}\left(p_{ir}+m_{ir}\right)^{-s_2} EXP_i}{\left[\sum_r a_{ir}\left(p_{ir}+m_{ir}\right)^{1-s_2}\right] + \left(1-\sum_r a_{ir}\right)\left(p_{ij}+m_{ij}\right)^{1-s_2}} \quad \forall r = 1,\ldots, j-1, \qquad (13)$$

where EXP_i is per capita expenditure on avocados from all supply regions in the ith demand region.

The values of the parameters b_{1i} and b_{2i} are determined in a similar manner. Because only one value needs to be chosen for each demand region and time period (a total of six values), the following single equation is solved for each value of b_i:

$$QI_i = \frac{b_i PI_i^{-s_1} I_i}{b_i PI_i^{1-s_1} + \left(1-b_i\right)}, \qquad (14)$$

where QI_i is the CES quantity aggregator which is defined as:

$$QI_i = \left\{\sum_j a_{ij}^{1/s_2} x_{ij}^{\frac{(s_2-1)}{s_2}}\right\}^{\frac{s_2}{(s_2-1)}}.$$

The calibrated values of, a_{1ij}, a_{2ij}, b_{1i}, and b_{2i} are reported in appendix 2 table 2.

Appendix 2 Table 2. Calibrated Base Shift Parameters

		Supply Region	
a_{1ij}	*California*	*Chile*	*Mexico*
Region A	0.3938959787	0.1364847381	0.4696192831
Region B	0.7058128644	0.2941871356	0.0
Region C	0.7185081783	0.2814918217	0.0
a_{2ij}	*California*	*Chile*	*Mexico*
Region A	0.8768944433	0.1231055567	0.0
Region B	0.8613266135	0.1386733865	0.0
Region C	0.8972646580	0.1027353420	0.0
		Demand Region	
	Region A	*Region B*	*Region C*
b_{1i}	0.0000330213	0.0000926161	0.0001395630
b_{2i}	0.0000398717	0.0001162266	0.0001808888

Revenue Function Parameters and Avocado Factor Endowment

The parameters d_r and b_r as well as the value of V_r must be chosen to calibrate the revenue functions for California and Chile. The value of b_r determines the elasticity of transformation or the ease with which avocado producers can shift their sales between the two time periods as relative producer prices of avocados between the periods change. The elasticity of transformation, s_{Tr}, is defined as:

$$s_{Tr} = \left(1 - b_r\right), \quad b_r \geq 1 \text{ and } \forall r = cal, ch \qquad (15)$$

No empirical estimates exist for the elasticity of transformation. It is assumed to be relatively small because historical seasonal production patterns have persisted over time even though avocados can be left on the tree for an extended period before harvesting. A base value of –0.5 for both regions, implying that b_r equals 1.5, is used in the model.

Given this value of b_r, the values of d_r and V_r are chosen so that the seasonal production patterns and the overall level of avocado production are replicated for the California and Chile supply regions. This is accomplished by substituting initial producer prices and production for each time period into equations (5) and (6) and solving that system of two equations for d_r and V_r. The calibrated values of the parameters of the revenue functions and V_r for California and Chile are listed in appendix 2 table 3.

In this model, the aggregate supply elasticity (h_{Ar}) is defined as:

$$h_{Ar} = \frac{\partial V_r}{\partial PP_r} \frac{PP_r}{V_r} = d_r \frac{PP_r}{V_r}. \qquad (16)$$

With a known value of h_{Ar}, equation (16) can then be used to determine the value of the parameter d_r. Given a value for d_r, the value of the parameter c_r can be calculated by solving:

$$c_r = V_r - d_r PP_r . \qquad (17)$$

Values of the parameters c_r and d_r for California and Chile are listed in appendix 2 table 3.

Appendix 2 Table 3. Revenue Function and Factor Supply Parameters

Revenue Function Parameters	d	b	V_r
California	0.34466537	1.5	376.66255157
Chile	0.60316145	1.5	122.59650054
Factor Supply Parameters	c	d	
California	244.83065852	146.32774671	
Chile	44.18850568	150.58099429	

Appendix 3. Baseline Quantity and Price Data

Table 1. Quantities of Hass avocados supplied by California, Chile, and Mexico, by time period and demand region, October 15, 2000 to October 15, 2002, pounds

Time Period 1

Demand Region A (northeastern and central States)

	California[1]	Chile[2]	Mexico[2]	TOTAL
10/15/00 to 4/15/01	22,676,863	10,744,924	24,575,434	57,997,221
10/15/01 to 4/15/02	13,776,988	9,656,129	52,324,560	75,757,676

Demand Region B (Pacific and southern States, except CA and FL)

	California[1]	Chile[2]	Mexico[2]	TOTAL
10/15/00 to 4/15/01	50,960,350	24,146,423	0	75,106,773
10/15/01 to 4/15/02	53,606,213	37,571,966	0	91,178,179

Demand Region C (California and Florida)

	California[1]	Chile[2]	Mexico[2]	TOTAL
10/15/00 to 4/15/01	57,619,300	27,301,617	0	84,920,917
10/15/01 to 4/15/02	57,606,113	40,375,450	0	97,981,563

Time Period 2

Demand Region A (northeastern and central States)

	California[1]	Chile[2]	Mexico[2]	TOTAL
4/15/01 to 10/15/01	63,263,038	9,955,413	0	73,218,450
4/15/02 to 10/15/02	61,995,388	14,075,114	0	76,070,502

Demand Region B (Pacific and southern States, except CA and FL)

	California[1]	Chile[2]	Mexico[2]	TOTAL
4/15/01 to 10/15/01	86,649,675	13,635,660	0	100,285,335
4/15/02 to 10/15/02	87,058,813	19,765,386	0	106,824,198

Demand Region C (California and Florida)

	California[1]	Chile[2]	Mexico[2]	TOTAL
4/15/01 to 10/15/01	101,372,738	15,952,561	0	117,325,298
4/15/02 to 10/15/02	96,672,775	21,948,090	0	118,620,865

(sources and notes, next page)

Appendix 3. Continued

Table 1. Continued

Sources: California quantities: based on data provided by the Avocado Marketing Research and Information Center (AMRIC). Chile and Mexico quantities: U.S. Census Bureau, as reported in the World Trade Atlas.
[1] AMRIC data are reported for terminal markets located within the six regions: Northeast, East Central, West Central, Pacific, Southwest, and Southeast. The Pacific region includes shipment terminals in Idaho and Utah. States currently approved to receive Hass avocados from Mexico correspond to those having terminal markets in AMRIC's Northeast, East Central, and West Central regions, plus Idaho and Utah. States with terminal markets in the Pacific, Southwest, and Southeast regions correspond to States prohibited from receiving Mexican Hass avocados, minus Idaho and Utah. Since the quantity of Hass avocados shipped to these two States is small, this discrepancy can be disregarded in using AMRIC's regional shipment data. April and October quantities are divided evenly between the two time periods.
[2] Avocado import data do not distinguish between whole fresh avocado imports and processed avocado imports. Quantities may therefore be somewhat inflated. Hass avocado imports began to be reported separately from other avocado imports in July 2001 (Harmonized Schedule 0804.40.0010). Reported import quantities from Chile and Mexico for October 2000 through June 2001 are multiplied by 99.6 percent and 98.8 percent, respectively, the percentages of imports identified as Hass from July 2001 through April 2003.
For imports from Chile for each time period, regional quantities are assumed to be proportional to regional shipments reported for California. For example, for the period 4/15/01 to 10/15/01, about 25 percent of Hass avocados supplied by California were shipped to the Northeast, East Central, and West Central regions; about 35 percent were shipped to the Pacific, Southwest, and Southeast regions, excluding California and Florida; and about 40 percent remained in California or were shipped to Florida. The same proportional shares are assumed for imports from Chile during this period. As with the California supply, April and October quantities supplied by Chile are divided evenly between the two time periods.
For imports from Mexico, April and October quantities are fully included within Period 1, given the relatively small amounts that are otherwise exported to Alaska (the only State allowed to receive Hass avocado imports from Mexico year-round) or processed. May through September shipments (imports of fresh avocados into Alaska and imports of processed avocados) are excluded from the analysis.

Appendix 3. Continued.

Table 2. Baseline Data Used in the Model

	Supply Region		
Quantity Demanded	California	Chile	Mexico
Time Period 1		Million Pounds	
Region A	18.226926	10.200527	38.449997
Region B	52.283282	30.859195	0
Region C	57.612707	33.838534	0
Time period 2			
Region A	62.629213	12.015264	0
Region B	86.854244	16.700523	0
Region C	99.022757	18.950326	0
Wholesale Prices			
Time period 1		Dollars per Pound	
Region A	1.5388	1.1956	1.1396
Region B	1.5648	1.3030	N/A
Region C	1.4653	1.1840	N/A
Time period 2			
Region A	1.4661	1.2439	N/A
Region B	1.5389	1.4016	N/A
Region C	1.4415	1.1000	N/A
Producer prices			
Time period 1	0.8775	0.5342	0.6327
Time period 2	0.9131	0.4998	N/A
	Demand Region		
	Region A	*Region B*	*Region C*
Per-capita income			
Time period 1	$16,047.58	$13,598.37	$15,898.56
Time period 2	$16,255.01	$13,824.79	$16,029.94
		Millions	
Population	146.236	85.167	50.518

Sources: Demand quantities: averages of quantities shown in appendix 3 table 1. Wholesale prices: Market News Archive, USDA Agricultural Marketing Service, Wholesale Market Fruit Reports (various issues). Producer prices: California avocado prices are FOB prices reported by the California Avocado Commission, and Chilean and Mexican prices are unit import prices reported by USDA FAS. Per capita income: State quarterly personal income from U.S. Department of Commerce, Bureau of Economic Analysis. Population: mid-year State population estimates from U.S. Census Bureau.

Appendix 4. Approach Used for the Sensitivity Analysis

The sensitivity analysis is performed using symmetric order three Gaussian quadratures. Stroud (1957) has shown that for a symmetric distribution, such as the uniform or triangular, the model needs to be resolved only 2*n* times, where *n* is the number of exogenous variables or parameters, in order to conduct a systematic sensitivity analysis. Arndt and Hertel (1997) have shown that systematic sensitivity analyses conducted using order three quadratures are as accurate as higher order quadratures.

Values for the random exogenous variables (or parameters) are chosen using the following procedure. Let n be the number of exogenous variables to be included in the sensitivity analysis. Then let $\Gamma_k = (g_{k1}, g_{k2}, \ldots, g_{kn})$ be the *k*th quadratures point, where $k = 1, 2, \ldots, 2n$. Then define an integer $r = 1, 2, \ldots, z$ such that z does not exceed $n/2$. For example, if n equals 5, then r would equal 2 because r cannot exceed 5/2. Elements of the Γ matrix are then chosen using the following formulas:

$$g_{k,2r-1} = \sqrt{2}\cos\left[\frac{(2r-1)kp}{n}\right], \text{ and} \qquad (19)$$

$$g_{k,2r} = \sqrt{2}\sin\left[\frac{(2r-1)kp}{n}\right]. \qquad (20)$$

Note that if n is an odd number, then $g_{kn} = (-1)^k$. The values of the random exogenous variables for each quadratures point are then determined using the following formula:

$$\Phi = m + \Gamma\sqrt{\Sigma}\,, \qquad (21)$$

where Φ is a ($2n$ x n) matrix of values for the exogenous variables, m is a ($2n$ x n) matrix of the means of the exogenous variables, Γ is a ($2n$ x n) matrix defined above, and Σ is a (n x n) diagonal variance/covariance matrix for the exogenous variables. Note that if all of the exogenous variables are independent, as is assumed here, then Σ will be a diagonal matrix.

Appendix 5. Equivalent Variation

Equivalent variation is defined as:

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

where e is the expenditure function, p^0 is the base or current price vector, u^0 is be base level of utility, and u^1 is the level of utility obtained by removing restrictions on Mexican avocado imports. The expenditure function is derived from the utility function (appendix 2 equation 1) and is defined for the representative consumer from the ith demand region as:

$$e_i\left(p_i, u_i\right) = \left\{ b_i \left(\sum_j a_{ij} \left[p_{ij} + m_{ij} \right]^{1-s_2} \right)^{\frac{1-s_1}{1-s_2}} + \left(1 - b_i\right) PE^{1-s_1} \right\}^{\frac{1}{1-s_1}} u_i \,. \qquad (22)$$

Note that since the expenditure function is linear in utility, EV for the representative consumer can be expressed as:

$$EV_i = \left\{ b_i \left(\sum_j a_{ij} \left[p_{ij}^0 + m_{ij} \right]^{1-s_2} \right)^{\frac{1-s_1}{1-s_2}} + \left(1 - b_i\right) \left(PE^0\right)^{1-s_1} \right\}^{\frac{1}{1-s_1}} \left(u_i^1 - u_i^0\right), \qquad (23)$$

where base period prices and utility are denoted by a 0 superscript. The base level of utility and the level of utility after the lifting of the import restrictions may be computed from the indirect utility function, which is derived from equation (23). To obtain the total level of EV, equation (23) is multiplied by the population in the ith demand region.