US Avocado (*Persea Americana Mill.*) Price Trend Analysis and Forecast, 2011–2014.

Abstract

During the VI World Avocado Congress in Chile, a model that forecasts U.S. avocado farm gate prices from 2007/08 to 2011/12 was presented. At that time the main concern was the impact on prices in the U.S. market as Mexico was allowed to ship avocados year-round. Since then the landscape has undergone significant changes: the 2009/10 U.S. crop production was higher than expected; Peru entered the U.S. avocado market; there has been a global financial crisis and recession; and there has been stricter enforcement of U.S. immigration laws and enforcement of minimum wage. This paper updates the forecast, taking into consideration some of these recent events and forecast prices over the 2010/11 to 2013/14 period.

Keywords: Avocado, avocado demand, avocado price forecast

INTRODUCTION

At the Sixth World Avocado Congress, in Chile, we presented a mathematical model that forecasts the average farm gate price of avocados in the U.S. market over the four-year period of 2008 to 2011. At that time, the concern revolved around the likely impact that would result from the decision to allow year-round shipments of Mexican avocados to all states in the United States. Specifically, the fear was that the U.S. market for avocados would become oversupplied/saturated from the increased market access granted to Mexico, the world's largest producer of avocados, causing considerable downward pressure on prices. Our model indicated that such fears were largely unfounded and predicted that even though prices were likely to fall slightly, there would not be a significant decline. Since that time, we have had a global financial crisis, a severe downturn in the U.S. economy, a new entrant to the U.S. avocado market, and stricter enforcement of U.S. immigration laws. The main objective of this paper is to update the forecast, taking into consideration some of these recent events and forecast prices over the 2011–

2014 period. The paper also discusses some the main demand and supply drivers likely to influence the market price.

BACKGROUND

U.S. production of avocados occurs in three states: California, Florida, and Hawaii. Historically, California has been the largest U.S. avocado producer, accounting for about 90% of the production, followed by Florida with about 9%, and Hawaii with less that 1%. California grows mainly Hass avocados (characterized by purplish-black skin) in San Diego, Riverside, Ventura, and Santa Barbara Counties. Florida avocados have green skins and are grown mainly in Miami-Dade County.

In 2009, the United States was the world's third largest avocado producer, with 268,000 tonnes, after Mexico with 1.01 million tonnes and Chile with 328,000 tonnes; the United States accounted for about 7% of the global production, while Mexico and Chile accounted for 32% and 9%, respectively (Table 1). As can be seen in Table 1, the U.S. avocado production exhibits long-term upward growth trend, with production increasing from 166,300 tonnes 1999 to 268,700 tonnes in 2009 (FAOSTAT). The erratic pattern observed can be explained by alternate (biennial) bearing years and inclement weather. U.S. production in 2008 was unusually low due to the October 2007 California wildfires affecting approximately 10% of the U.S. Hass avocado production (USDA Market News January 2008).

Although the United States is a major producer of avocado, it is also the largest import market. Since the late 1980s, the United States has become a net importer of avocados. In 2002, the United States overtook France to become the world's number one importer of avocados. U.S.

avocado imports reached 431,733 tonnes in 2009, a 23.7% increase over the previous high of 314,837 tonnes recorded in 2008 and an almost six-fold increase over the 78,532 tonnes imported in 2000 (USDA/ERS). Figure 1 shows the trend in U.S. imports of avocados over the period 2000–2010.

The main suppliers of avocados to the U.S. market are California, Mexico, Chile, and the Dominican Republic. Hass cultivars are imported from Mexico, Chile, and New Zealand, and the green-skinned cultivars are imported from the Dominican Republic. Mexico, Chile, and the Dominican Republic, with shares of 77%, 18%, and 4.3%, respectively, dominate the U.S. avocado import market, accounting for 99% of the total imports in 2010.

As illustrated in Figure 2, up until 2004, the main overseas supplier of avocados to the United States was Chile, followed by Mexico and the Dominican Republic. However, this situation was reversed in 2005, when Mexico more than tripled the amount of avocados it exported to the United States (from 38,676 tonnes in 2004 to 134,316 tonnes in 2005). This represented an increase of about 95,000 tonnes (352%) over the previous year. In comparison, imports from Chile increased by 21,252 tonnes (22%) to reach about 114,000 tonnes for the same period.

Recently, the U.S. Department of Agriculture’s Animal Plant Health Inspection Service (APHIS) announced that it was amending its regulations to allow, under certain conditions, the importation of Hass avocados from Peru into the continental United States. Such conditions include regulating grove sanitation, trappings, surveys, and registration, and monitoring production places and packinghouses. In addition, the avocados must be accompanied by a phytosanitary certificate and a written declaration stating that the avocados had been inspected and found to be free of pests in accordance with APHIS requirements. Previously, Hass avocados from Peru were not allowed into the United States because the pest risk had not been analyzed. Avocados from Peru will further increase the year-round availability of the fruit as the Peruvian season comes at a time when the supply from Mexico is low.

California's avocado planted area has been on the decline; the total number of producing hectares in California for the 2010/11 season is 21,072, compared to 26,620 producing hectares in 2005, or about a 20% reduction. In 2010/11 production number by variety included Hass variety, 19,648 hectares; Lamb-Hass variety, 888 hectares; and other varieties, 536 hectares (California Avocado Commission). Even after the number of new plantings (1,365 hectares) is factored in, the net change until 2010/11 is still negative (–3,822 hectares) when compared to the planted area in 2005. Florida's avocado planted area has increased slightly, from around 2,500 hectares in 2002 to 2,850 hectares in 2010.

The combined effects of the economic crisis and the stricter enforcement of immigration laws in the United States have reduced the unauthorized immigrant population; this populace in the United States was estimated to be about 11.78 million in 2007, compared to 10.75 million in 2009. In the case of California, the estimated unauthorized immigrant population in California was 2.84 million in 2007, compared to 2.60 million in 2009 (Public Policy Institute of California 2010).

The U.S. agricultural industry relies on the labor of unauthorized immigrants. The share of hired crop farm workers not legally authorized to work in the United States totaled almost 55% in 1999/01 and has fluctuated around 50% since then (USDA/ERS). Labor cost represents a significant percentage of the harvest, marketing, and inspection costs for avocados. Assuming a yield of 8.2 metric tonnes per hectare, picking costs account for 80% of the harvest, marketing, and inspection costs, and about 15% of the total production costs for an established avocado orchard in California (Takele et al. 2002). Any legislation that constrains the availability of farm workers will have negative consequences, as the reduced supply of labor for avocado and other crops could increase harvest costs, thereby reducing the competitiveness of the U.S. avocado industry. In addition, the U.S. authorities are enforcing the minimum wage law of $7.25 per hour, which involves fines for contractors and growers in violation of the law. This has had the effect of increasing production costs.

Mexico's avocado planted area is expected to increase. In 2010/11, it reached 132,036 hectares, 2% higher than the planted area in the previous year. For 2010/11, the Animal and Plant Health Inspection Service (APHIS) has certified 56,645 hectares of Mexican avocados as eligible for export to the United States. Phytosanitary authorities in the state of Michoacan (Mexico) have requested APHIS to certify 62,928 hectares of avocado for export to the United States. Michoacan producers, supported by their avocado association, have invested nearly $2 million in technological improvements to guarantee that their avocados meet the highest quality and safety requirements (USDA/FAS). While most of Mexico's avocado production is grown for the domestic market, attractive prices in the export market will encourage more exports. Chile's avocado planted area is expected to increase, but at a slower rate, as prices have leveled off and growers' margins have decreased due to the revaluation of the Chilean peso against the dollar. Because of the weaker dollar, the domestic and EU (European Union) markets are increasingly gaining the attention of Chilean growers (USDA/FAS).

In the last decade, U.S. per capita consumption of avocado has risen significantly, from 1.0 kilogram (kg) in 2000 to 1.86 kg in 2010, representing an annual growth rate of about 6.4%. The most notable change in consumption occurred from 2002 to 2005, when the annual growth rate for this four-year period was 10% (Figure 3). U.S. per capita consumption of avocado is still substantially lower than that of Mexico (6.62 kg) and Chile (5.58 kg), although relatively high per capita consumption can be found in regions with large Hispanic population.

The rise in U.S. avocado consumption is attributable to several factors, chief among such factors is the increased import volume coming mainly from Mexico. Other factors include: an increase in the U.S. Hispanic population, product availability and health benefits, advertising, and higher personal income. Hispanics are the largest and fastest growing ethnic group in the United States, accounting for about 16.3% of the total U.S. population in 2010. According to the U.S. Census Bureau (2011), between 2000 and 2010, the total U.S. population increased by 9.7%, from 281 million to 308 million (0.96% annual growth rate), while the U.S. Hispanic population increased by 43%, from 35.5 million to 50.5 million (3.6% annual growth rate).

Sourcing avocados from different geographic regions has resulted in year-round availability of the fruit in local groceries, food markets, and restaurants. In addition, as consumers become more health conscious, the demand for healthier food products (functional foods) also increases. Several studies have found that avocados contain antioxidants known to slow the aging process and to protect against heart disease and various forms of cancer (Lu et al. 2005; Rosenblat et al. 2011). Advertising and marketing provides consumers with information about the advantages of consuming avocados. For example, in 2005, the California Avocado Commission spent approximately $13 million on advertising and promotional activities to tout the nutritional and health benefits of avocados through outreach efforts, and in 2008, it launched a program to tout the benefits of California avocados through personal stories about California’s growers.

Until recently rising per capita income was another factor driving the increased consumption of avocados in the U.S.A. In general an increase in per capita income is associated with an increase in the quantity of avocados demanded and vice versa. Between 2000 to 2007 per capita disposable income grew at an annual rate of 2%, but slowed considerably to a mere 0.33% from 2007 to 2010.

In the last ten years, the average grower price of U.S. avocados has fluctuated from a high of $2.11/kg in 2002/03 to a low of $1.24/kg in 2005/06, when domestic production reached an historic record of 314,500 tonnes. The 2009/10 price of $1.42/kg was 22% below the five-year average of $1.73/kg and 70% below the price obtained in 2002/03.

MATERIAL AND METHODS

Model Specification

In traditional demand analysis, quantity is the function of several variables, such as prices and income. An alternative approach for demand analysis is inverse demand, which has gained acceptance as a tool of empirical economics, especially in agriculture and natural resource markets, as conditions of supply signal that quantities are predetermined (Park and Thurman 1999). It has long been recognized that lags between farmers' decisions on production and marketed commodities may predetermine quantities, with price adjustments providing the market-clearing mechanism. Therefore quantities are appropriate variables in the analysis of many types of agricultural policies and problems (Huang 1998). In the inverse demand approach, prices are functions of quantities demanded, income, and other variables. Per capita consumption of avocados and the price of any complement should vary inversely with the price of avocados, while the price of other fresh fruits and income (assuming the good is normal) is expected to have a positive relationship with the avocado price.

The functional form for avocado inverse demand equation can be written as:

$$P = f\,(Q_A, Q_{OF}, I) \qquad (1)$$

The econometric specification of the price forecasting model is as follows:

$$\ln P_t = \alpha + \beta_1 \ln Q_{A,t} + \beta_2 \ln Q_{OF,t} + \beta_3 \ln I_t + \varepsilon_t \qquad (2)$$

where

α = Intercept

P_t = U.S. avocado price in year t

$Q_{A,t}$ = Per capita consumption of avocado in the U.S. in year t

$Q_{OF,t}$ = Per capita consumption of other fresh fruits in the U.S. in year t

I_t = Per capita disposable income in year t

ε_t = Error term

t = Year t subscript.

The estimated parameters of the inverse demand model specified above are known as own price flexibility (β_1), cross price flexibility (β_2), and income flexibility (β_3), respectively. Data on U.S. avocado farm gate prices from 1980 to 2009, per capita consumption of avocado in the United States, and per capita consumption of other fresh fruits from 1980 to 2009 were obtained from the Economic Research Service of the United States Department of Agriculture. Per capita disposable income from 1980 to 2009 was obtained from the Bureau of Economic Analysis of the United States Department of Commerce.

Ordinary least squares (OLS) regression was used to estimate the coefficients of the avocado price forecasting model for the 1980–2009 period using SAS 9.2®. In order to verify the validity of the parameters estimated, residuals of the avocado price forecasting regression model were tested for autocorrelation and heteroskedasticity. Autocorrelation if present violates the OLS assumption that the error terms are uncorrelated, and results in estimated parameters that even though they are unbiased, are inefficient. Additionally, any test of significance will be misleading because it is based on the wrong covariance matrix (Maddala 2001). The Breusch-Godfrey test, also known as the Lagrange Multiplier (LM) test, was used to test for autocorrelation. Heteroskedasticity occurs when the variance of the residuals increased or decreased in a systematic manner. Under heteroskedasticity, the least square estimators are unbiased but inefficient, and the inappropriate standard errors obtained will lead to invalid hypothesis tests. The Breusch-Pagan-Godfrey (BPG) test was used to test for heteroskedasticity.

Forecasting

Avocado prices for the 2010/2011 to 2013/2014 season are projected using the avocado price forecasting regression model. In order to do so, it was necessary to provide future values for the exogenous variables in the forecasting equation. Such values can be obtained from other studies or by assuming that recent trends in the past will continue in the near future. In this case, it is assumed that per capita consumption of avocado and per capita consumption of other fresh fruits in the United States can be predicted using the moving average method with data from the 2007–2009 period. Predicted per capita disposable incomes in the United States from 2010 to 2013 are taken from IBISWorld.

In order to assess the predictive accuracy of the forecasting model, the performance of the model was evaluated in terms of several forecast evaluation statistics such as the mean error (ME), the mean absolute error (MAE), the mean squared error (MSE), the root mean square error

(RMSE), and Theil's U-statistics. Theil's U-statistics are presented in both specifications, which are labeled U_1 and U_2, respectively (Theil 1966) (See Appendix).

RESULTS

Results for the econometric estimation are shown in Table 2. The R-squared term indicates a good predictive validity of the model, as 89 % of the variation in the price of avocado is explained by the variables selected. All the estimated parameters are statistically significant at the 1%, except per capita consumption of other fruits, which is significant at the 5% level. The estimated direct price flexibility for per capita consumption of avocado of -1.448 indicates that a 10% increase in the supply of avocados in the market is likely to cause the price of avocado to decrease by 14.48%. In other words, if the supply of avocados in the U.S.A increased by about 60,000 tons price would fall by about $0.20 per kg, if all other factors remained the same. The estimated cross price flexibility between the price of avocado and the per capita consumption of fresh fruits of –2.701 indicates that the two product categories are substitutes. A marginal 1% increase in the quantity of other fresh fruits is associated with a 2.70% decrease in the price of avocado to induce consumers to purchase the same quantity of avocado. Residuals of the regression model are tested for autocorrelation and heteroskedasticity. The income flexibility for avocado of 5.14 indicates that a 1% increase in per capita disposable income is likely to increase the demand for avocados causing the price of avocado to increase by about 5.14%, assuming other factors remained constant.

The results from the Lagrange Multiplier test to check if the residuals are correlated indicates that the residuals from the estimated model do not exhibit autocorrelation (Pr >LM, 0.786) or heteroskedasticity (Pr >Chi Square, 0.226). In a forecasting model, the ability to predict turning points is obviously important. The actual values and predictions from the avocado price forecasting model are shown in Figure 4. The avocado price forecasting model can predict almost all of the turning points. In addition, all forecast evaluation statistics are very low (Table 3), meaning that the price forecasts from the proposed model are highly reliable.

DISCUSSION

The model predicts that after the sharp decline during 2009/10, avocado prices in the United States are likely to start rising gradually from $1.63/kg in 2010/11 to reach $2.05/kg in 2013/14; the forecast annual growth rate for avocado prices will be about 6% for the time period projected.

Avocado prices in 2010/11 are likely to increase as a result of expectations of low supplies; California avocado production for that period is estimated to be 107,000 tonnes, which is about half the bumper crop registered in 2009/10 (California Avocado Commission). Chilean avocado production also is expected to decline for 2010/11 as a result of adverse weather and the alternative bearing effect after the record crop in the 2009/10 season (USDA/FAS). Mexican avocado production is forecasted to decline, as 2011 is the low year in the alternate bearing cycle and harsh weather conditions are expected, although as new trees come into full bearing this season, this will make up to a certain extent the anticipated decline in production (USDA/FAS).

The tendency to import most of the avocados consumed in the U.S. market will continue, with Mexico and Chile as the main suppliers. Domestic avocado production is not expected to increase significantly after 2011/12, as the number of bearing hectares in California has experienced a downward trend since 2005, and the new plantings do not make up for the lost area, resulting in a net decrease in terms of the planted area. Any increases in domestic production will be due mainly to the alternate or irregular bearing effect and a benevolent weather.

Chilean avocado exports to the U.S. market are not expected to grow significantly after 2011/12, as a forecasted weaker dollar in addition to increasing production costs will reduce growers' margins. Therefore a large number of producers will favor the less risky domestic market where prices are similar to those on international markets. In contrast, Chilean avocado exports to the European Union are expected to grow as a result of a market diversification campaign and a stronger Euro. Mexican avocado exports to the United States are expected to grow and compensate any decline in imports from Chile; as new orchards are coming into production, the number of hectares certified by the APHIS as eligible for export to the United States will increase, and technological improvements will ensure a fruit with a higher quality. Although Peru has begun exporting to the United States, it is not expected that supplies will have a significant impact on prices, as the amount is relatively small and enters the market when supplies from Mexico is low.

On the demand side, even though the recession in the United States officially ended in July 2009, its effects are still being felt as high unemployment rate persists and the decline in home values continues. U.S. per capita disposable income is forecasted to grow at a modest annual rate of 1.7% from 2010/11 to 2013/14. During the early months of 2011, U.S. consumers experienced a sharp increase in food and energy prices, and as long as this situation remains unchanged, consumer expenditures in fresh fruits are expected to decrease as result of a reduced purchasing power. However avocado may be an exception as there is evidence to suggest that consumption of avocados has been immune to the adverse impacts of the recession.

Growth for the U.S. Hispanic population will depend upon several factors, such as the pace of the economic recovery and the enforcement of stricter immigration policies. Even though there are fewer unauthorized immigrants, the overall size of the U.S. Hispanic population is still a significant factor that continues to drive avocado consumption in the United States.

Promotional activities will play an important role to offset factors such as the low growth of personal income and to stimulate the consumption of avocado by new consumers. In 2009, the Hass Avocado Board, the Mexican Hass Avocado Importers, and the Chilean Importers Association joined efforts for the first time to conduct a promotional campaign for Hass avocados. Because market timing for Hass avocados differ (i.e., California avocados are in peak supply from February to September, Chilean avocado are available between September and February, and Mexican avocados are available year-round), it is expected that joint promotional campaigns will continue in the near future and boost consumption. This we believe will be the main factor that will continue drive the demand for avocados offsetting anticipated slow down in the U.S. economy and any price depressing effects resulting from increased imports.

Based on the above supply and demand factors, the model forecasts that avocado prices in the U.S. market are likely to rise gradually, perhaps reaching $2.055/kg in 2013/14, which is below the all-time high of $2.38/kg in 1998/99.

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Appendix: Forecast Evaluation Statistics

Denoting a series of corresponding actual outcomes as A_t and a forecast of it as F_t, the forecast error results in $e_t = A_t - F_t$, for $t = 1,...,T$ where T represents the number of observations. Using this notation, the set of forecast evaluation statistics considered are as follows:

$$ME = \frac{1}{T}\sum_{t=1}^{T}(A_t - F_t) = \frac{1}{T}\sum_{t=1}^{T}e_t \tag{3}$$

$$MAE = \frac{1}{T}\sum_{t=1}^{T}\left|A_t - F_t\right| = \frac{1}{T}\sum_{t=1}^{T}\left|e_t\right| \tag{4}$$

$$MSE = \frac{1}{T}\sum_{t=1}^{T}(A_t - F_t)^2 = \frac{1}{T}\sum_{t=1}^{T}(e_t)^2 \tag{5}$$

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(A_t - F_t)^2} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(e_t)^2} \tag{6}$$

$$U_1 = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(A_t - F_t)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}A_t^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}F_t^2}} = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(e_t)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}A_t^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}F_t^2}} \tag{7}$$

$$U_2 = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(A_{t+1} - F_{t+1})^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(A_{t+1} - A_t)^2}}. \tag{8}$$

The mean error (ME) provides information on the long-term performance. A low ME is desirable, as the closer the ME is to zero, the more accurate is the estimate. A positive ME value gives the average amount of overestimation in the calculated values, while a negative ME suggests underestimation (Tomek and Robinson 2003). A simple way to avoid the compensation of positive and negative forecast errors is to consider mean absolute error (MAE). The MAE gives the absolute value of the bias errors. Although the MAE is more resistant to outlier errors, the mean squared error (MSE) is more often used in practice. The MSE of zero represents a perfect forecasting model. However, because the MSE is simply relative to zero, no benchmark level of the MSE exists to tell a forecaster whether or not the model is appropriate. An alternative way of examining the size of forecast errors is the root mean square error (RMSE). The RMSE test gives information on the short-term performance of the correlations by allowing a term-by-term comparison of the actual deviation between the estimated and measured values. The lower the RMSE, the more accurate is the estimate. However, the RMSE does not distinguish between under- and over-predictions. Furthermore, there is no theoretical upper bound for the RMSE (Tomek and Robinson 2003).

Like RMSE, Theil's U-statistics cannot distinguish between under- or over-prediction, but the magnitude of error can be examined from the inequality coefficients (U). U will be zero when the forecast is perfect. The statistic U_1 is bounded to the intervals 0 and 1. A value of 0 for U_1 indicates perfect prediction, while a value of 1 corresponds to perfect inequality or negative proportionality between the actual and predicted values. This means that the more accurate the forecast, the lower is the value of the U_1 statistic (Tomek and Robinson 2003).

Statistic U_2 is bounded by 0, the same as U_1, with perfect forecasts. A U_2 value of 1 indicates that forecasts are no better than the naïve no-change extrapolation. However, it has no upper bound and takes on a value of 1 when the prediction method is the no-change extrapolation (Leuthold 1975). Consequently, U_2, as opposed to U_1, can take on values greater than 1 for models less accurate than no-change extrapolations. Therefore numbers closer to zero are preferred to numbers farther away.

TABLES

Table 1: World's top 10 avocado producers, 1999–2009 (thousand metric tonnes)

Countries	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Share (%) 2009
Mexico	879.1	907.4	940.2	901.1	905.0	987.0	1021.5	1134.3	1142.9	1124.6	1231.0	0.32
Chile	82.0	98.0	110.0	140.0	140.0	160.0	160.0	205.0	260.0	331.0	328.0	0.09
USA	166.3	217.1	202.6	180.9	211.7	162.7	283.4	247.0	193.1	116.0	268.7	0.07
Indonesia	126.5	145.8	141.7	238.2	256.0	221.8	227.6	239.5	201.6	225.2	257.9	0.07
Dominican Republic	71.2	81.7	111.1	147.5	273.7	218.8	113.6	216.4	183.5	187.4	184.4	0.05
Colombia	158.5	131.7	137.1	142.7	163.2	171.0	171.6	191.7	194.0	184.0	165.2	0.04
Peru	78.0	83.7	93.5	94.2	100.0	108.5	103.4	113.3	121.7	136.3	156.0	0.04
Brazil	86.4	86.1	154.2	173.9	156.7	170.5	169.3	164.4	154.1	147.2	139.1	0.04
China	70.0	70.0	74.5	75.0	81.0	100.0	125.0	90.0	92.0	95.0	100.0	0.03
Others	782.8	885.0	885.5	920.2	950.1	961.7	1080.7	1031.8	1110.1	1070.5	1023.7	0.27
World Total	**2500.8**	**2706.5**	**2850.3**	**3013.7**	**3237.3**	**3261.9**	**3456.2**	**3633.3**	**3653.0**	**3617.1**	**3853.9**	

Source: FAOSTAT 2011

Table 2: Avocado Price Model Regression Estimates for U.S. Avocado, 1980–2009

Variable	Coefficients	Standard Error	t Value	Pr > |t|
Intercept	–39.6034 (α)	3.0214	–13.11	<.0001
ln Q_A	–1.4488 (β_1)	0.1616	–8.97	<.0001
ln Q_{OF}	–2.7011 (β_2)	1.1587	–2.33	0.0278
ln I	5.1488 (β_3)	0.4990	10.32	<.0001

	R^2	Adjusted R^2	Standard Error	Observations
	0.897	0.885	0.192	30

ANOVA

	Degree of Freedom	Sum of Square	Mean Square	F Value
Regression	3	8.426	2.808	76.01
Residual	26	0.960	0.036	
Total	29	9.387		

Heteroskedasticity Test

Test	Statistic	Degree of Freedom	Pr > Chi Square
Breusch-Pagan	5.65	4	0.226

Godfrey’s Serial Correlation Test

Lagrange Multiplier	Pr >LM
0.073	0.786

Table 3: Forecast Evaluation Statistics

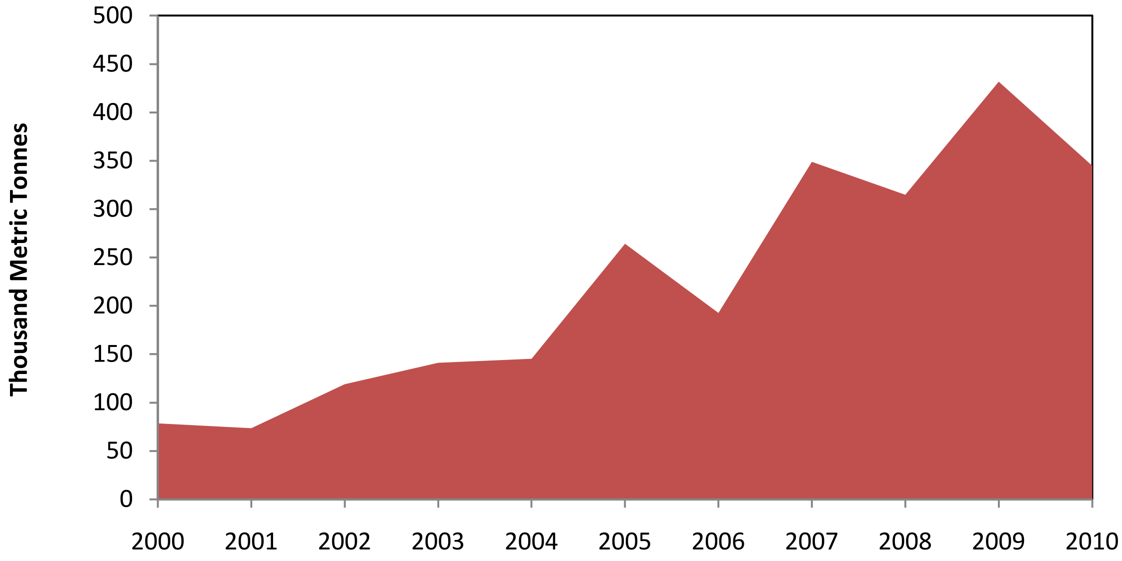
Evaluation Measures	**Statistics**
Mean Error (ME)	2.5E-15
Mean Absolute Error (MAE)	0.1344
Mean Squared Error (MSE)	0.0315
Root Mean Squared Error (RMSE)	0.1775
Theil's U_1 Statistic (U_1)	0.0198
Theil's U_2 Statistic (U_2)	0.1169

Table 4: Avocado Price Model Forecasts, 2007–2011

Season	Price ($/Kg)	Per capita Consumption (Kg)		Per capita Personal Disposable Income ($)
		Avocado	All other fresh fruits	
2010/11	1.63	1.73	43.66	28,649
2011/12	1.72	1.77	43.49	28,878
2012/13	1.87	1.78	43.70	28,849
2013/14	2.05	1.76	43.69	29,282

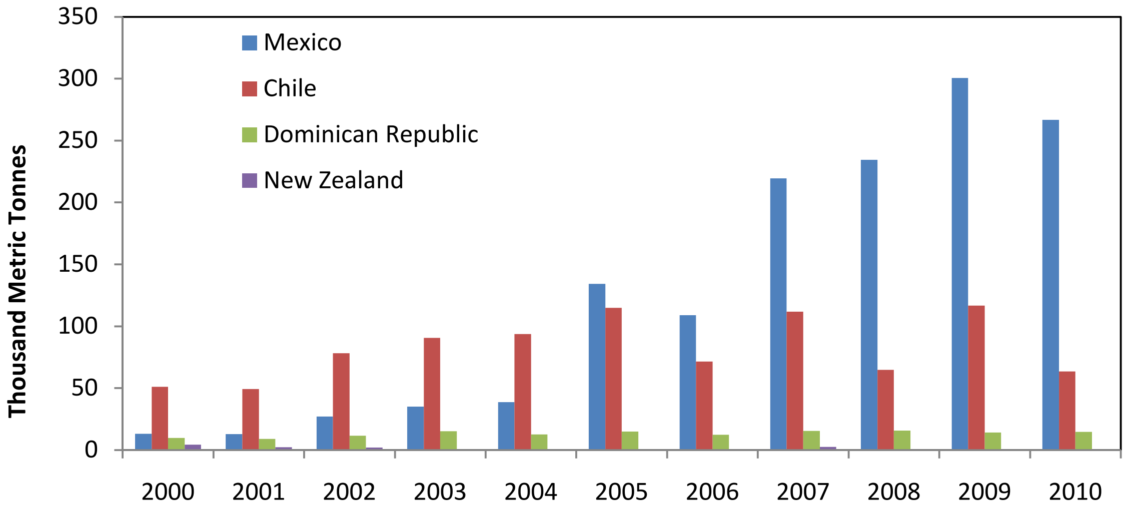
FIGURES

Figure 1: Total U.S. avocado imports, 2000–2010 (1,000 metric tonnes)



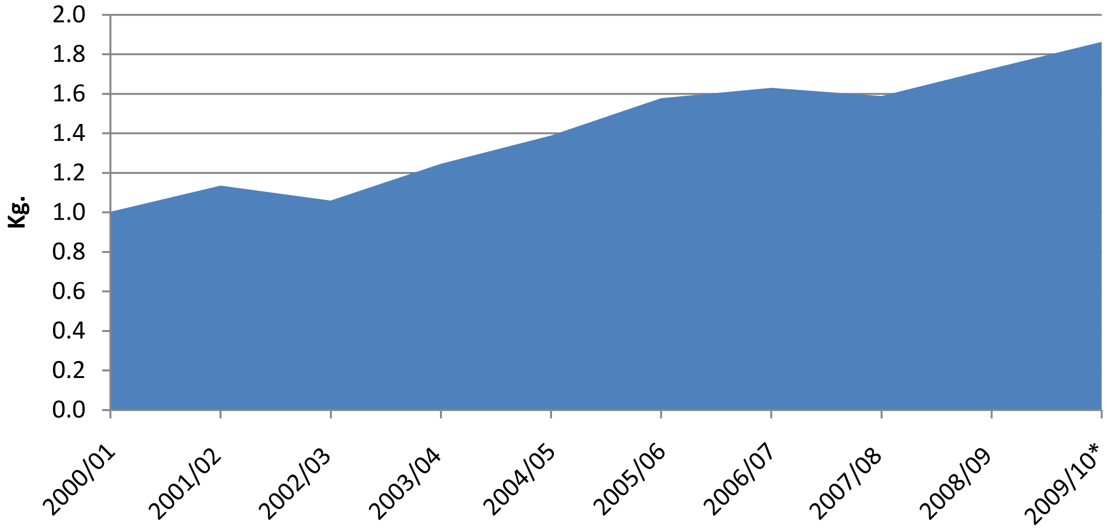
Source: USDA FAS

Figure 2: Top four exporters of U.S avocado imports, 2000–2010 (1,000 metric tonnes).



Source: USDA FAS

Figure 3: U.S. per capita consumption of avocado, 2000/01–2009/10 (kilograms).



Source: USDA ERS

Figure 4: U.S. avocado observed versus predicted price, 1980/81–2013/14 ($/kg).