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WP 93-02

UCD Department of Agricultural Economics

Almonds -- Marketing

DEMAND AND SUPPLY RELATIONSHIPS AND MARKETING STRATEGIES FOR CALIFORNIA ALMONDS: A SUMMARY REPORT

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WORKING PAPER SERIES

22764

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Department of Agricultural Economics

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This report summarizes a study of the California almond industry conducted over a two-year period by the Department of Agricultural Economics at the University of California-Davis. The study was initiated in response to a request issued by the Almond Board of California for proposals to analyze demand and supply relationships in the almond industry and to investigate marketing strategies relating to reserve policy.

The study involved several phases, each of which is discussed here in summary form. Detailed reports on the various phases of the study have also been prepared and are available for inspection or are currently under preparation.

The first two phases of the study involved econometric analysis of demand for almonds in 15 major consuming countries and estimation of supply relationships for the world's two major almond producers, California and Spain. Results from the supply and demand analyses are summarized in sections I and II, respectively. Next, these supply and demand relationships were aggregated and linked through market equilibrium conditions to develop two integrated, dynamic policy models of the world almond market. These models may be used to simulate the response over time of almond production, prices, and revenue to alternative reserve policies or external shocks (such as a change in tax policy) that may impact upon the industry.

Formulation and validation of the simulation models is discussed in section III. Applications of the simulation model to forecasting, policy analysis, and reserve strategy are discussed in section IV.

I. Almond Production in California and Spain

Over the past 25 years California has become the world's dominant producer and exporter of almonds, but Spain remains an important international competitor. For the three marketing years 1989-90 through 1991-92, California accounted for an average of 66.3% and Spain an average of 17.1% of world almond production. The two combined for an even greater percentage of world exports: 80.1% for California and 15.9% for Spain. Almond exports for other producing countries (Greece, Italy, Morocco, Portugal, and Turkey) account in combination for only 4.0% of world exports and, thus, these countries are minor players in the world almond market.

California almond acreage more than doubled during the 1960s, reaching 232,300 acres in 1970. Growth continued during the 70s, reaching 389,000 acres by 1980. Expansion slowed in the 1980s with total almond acreage reaching 431,900 by 1990. Spain experienced a similar explosion of almond acreage during this period, rising from 407,700 in 1960 to 1,516,100 in 1990. The major growth phase occurred in the 1970s when 550,000 acres were brought into almond production. Spanish yields on average are much lower than California yields (1996 lbs./acre in shell for 1985-89 in California vs. Spanish yields of 388 lbs./acre in shell for the same period), resulting in California's significant production advantage. The UCD study of almond supply in California and Spain involved analysis of factors determining both (i) average yields, and (ii) bearing acreage resulting from plantings and removals of almond trees.

<u>Almond yield forecasting models for California and Spain</u>: Total almond production in a given year is the product of bearing acreage and average yield. Because recommendations for reserve policy must be made by the Almond Board to the Secretary of Agriculture before the harvest occurs in either California or Spain, reliable methods to forecast yield in both California and Spain are critical to the successful exercise of reserve policy.

Currently, the industry relies upon California crop forecasts made by the California Agricultural Statistics Service (CASS), which produces a "subjective" forecast after the spring bloom set and an "objective" forecast in late June based on measuring the nut content of a selected sample of trees. These methods have proven to be reasonably accurate but suffer the disadvantage that no forecast can be made until after the bloom is set in March. No formal mechanism for forecasting Spanish yields exists. Informal forecasts generated after the bloom period by major handlers suffer the same timing limitations as the CASS forecasts and have varied in their degree of accuracy.

The UCD yield models for California and Spanish almonds are based upon a statistical or econometric framework. The premise of this approach is that the past contributions to yield of various key yield-determining factors can be isolated and quantified using statistical procedures and, moreover, that these same factors will continue to influence future almond yields in the same manner as they did in the past.

A statistical model to explain the California average annual almond yield was estimated using data from 1950-90. The estimated yield equation is:

$$y_t = -0.071 - 1.007y_{t-1} + 0.363(y_{t-1}-y_{t-2}) + 0.040T_t - 1.166YB_t + 0.668OB_t - 0.057R_t$$

where y_t is yield in tons per bearing acre, in-shell weight
y_{t-1} is yield per acre lagged one year
$y_{t-1}-y_{t-2}$ is the change in yield between years t-1 and t-2
T_t is an annual time trend
YB_t is the proportion of bearing acreage 5-9 years old
OB_t is the proportion of bearing acreage over 20 years old
R_t is the average of February rainfall in inches measured in Chico, Fresno, and Modesto.

This equation succeeded in explaining 82% of the variation in average annual yields over the 1950-90 period.

The yield model documents a strong alternate bearing effect. Yield in year t is expected to be below (above) normal by roughly the same amount that yield in the prior year was above (below) normal. The positive effect on current yield of the change in yield for the previous year (y_{t-1} - y_{t-2}) suggests that some changes in yield persist for more than one year. The time trend documents a modest average increase in yields over the sample period. The coefficients on the proportion of bearing acreage in young vs. mature trees quantify the yield disadvantage of younger stock until it reaches maturity. Finally, the model quantifies the effect on yield from disruption of the bloom by February rain.

The model to forecast Spanish yield followed similar logic and methodology to the California model. Adaptations were needed to recognize that most Spanish acreage is dryland, so rainfall during the growing season is an important determinant of yields on this acreage. Separate yield equations for dryland, irrigated, and total acreage were estimated. As well, account was taken that some areas of production are threatened by frost in February. The Spanish yield models are reported in Table 1.

An advantage of these models as harvest forecasting tools is that preliminary forecasts can be made up to a year in advance of the harvest. This is particularly important because reserve policy decisions and marketing strategies should be based not only on the current supply but also on expected future supplies, due to almonds' storeability from one crop year to the next. Among the variables in the California yield model, all except February rainfall (for which a historical average may be used) are known a year in advance of the harvest.

Of course, updated forecasts can be generated once February rainfall is known. The

CASS subjective forecast also becomes available around this same time. Our statistical forecasting models are designed to complement the official CASS forecasts and various unofficial Spanish crop forecasts, with the primary advantage from our approach being the ability to obtain a tentative crop forecast up to a year in advance of harvest. The yield models also play important roles in the simulation models by quantifying changes over time in yield due to alternate bearing, trend, and age distribution of the tree stock.

Almond acreage response models for California and Spain: Whereas yields are determined largely by biological and weather factors out of the producer's control, plantings and removals are governed by grower decisions that presumably are based on economic factors. An understanding of the factors determining almond acreage response is crucial to the effective management of reserve policy because actions taken to raise prices and profits in the industry can be expected to stimulate new plantings that may undermine the effectiveness of reserve policy. New plantings may be made by (i) current California almond growers, (ii) entrants to the California industry, and (iii) growers outside the influence of the U.S. marketing order, namely those in Spain. The source of new plantings is also an important consideration in formulating reserve policy.

Because almonds are a perennial crop, decisions to invest in almond acreage are based upon the stream of income projected to accrue over the life of the investment. Our model of almond acreage response in California involved specifying the decision to plant almond acreage in a given year t as a function of the expected net present value of income from an investment in almond acreage in year t. Expected net after tax profits each year are the forecast revenues from almond sales less initial establishment costs and orchard upkeep and harvesting costs. To construct the expected net present value of an almond investment for each year t, these streams of forecast revenues and costs were adjusted for tax implications and discounted.

Net present value from investment in almond orchards was estimated for each year from 1961-90. Establishment costs for the first four years of an orchard and annual variable costs for harvest and maintenance were based on figures compiled by the UC Cooperative Extension Service. To compute the expected revenue stream, we began with a yield profile over the useful life of an almond orchard. Revenues per acre for a given year were then estimated to be expected yield times expected price. We assumed that the potential investor's forecast of future prices was based upon the immediate past price for almonds times a constant annual growth factor. Finally, these streams of projected revenues and costs were adjusted for income taxes, depreciation allowances, and, where appropriate, the investment tax credit. Table 2 presents the expected net present value (ENPV) estimates and corresponding discount rates for 1961-90.

The best statistical model of annual plantings of almond acreage in California specified plantings in year t to be a function of ENPV lagged one year of such an investment and the amount of plantings in the previous year. This model succeeded in explaining 78% of the variation in California plantings over the 1962-90 period. The estimated model is:

$$PLT_t = 7.581 + 0.00139ENPV_{t-1} + 0.4199PLT_{t-1},$$

where PLT_t denotes number of acres in thousands planted in almond orchard in year t. This equation is also part of the policy simulation models for the California almond industry. The almond-planting effect in California from any policy that influences almond revenues or costs can be forecast from this model simply by translating the effect (e.g., a reserve policy, change in tax laws, or increase in water costs) into a change in expected net present value. Predicted vs. actual plantings from the model for the 1962-90 period are illustrated in Figure 1.

In deciding whether to remove almond acreage from production, the grower must trade off the ENPV of revenue from the orchard's remaining years of life with the ENPV of an alternative crop that could be planted if almond trees were removed from the acreage. Even though the latter income stream is likely to be absolutely larger, it is discounted more heavily since revenues occur at more distant points in the future. The optimal age for removals, assuming the acreage is replanted in almonds, varies from year to year due to variation in the ENPVs, but in general our analysis suggests the optimal rotation period to be between 30-40 years and to be nearer to 30 years under current tax laws.

Given that removals decisions are made with a shorter time horizon than plantings decisions, the best statistical model to explain removals utilized profitability, π, of almond acreage in each of the previous four years (π_{t-1}, π_{t-2}, π_{t-3}, π_{t-4}), the lagged value of total investment in almond ACREAGE, and indicator variables (TAX) to account for tax law changes over the 1962-90 sample period:

$$REMOVALS_t = 5119 - 5.025\pi_{t-1} - 7.855\pi_{t-2} - 14.05\pi_{t-3} - 3.247\pi_{t-4} + 5.271ACREAGE_{t-1} - 2060TAX1 + 2595TAX2 + 468TAX3.$$

This model succeeded in explaining 71% of the annual variation in removals from 1962-90. Predicted vs. actual removals during this period are illustrated in Figure 2. The results of the model are very intuitive. The greater the short-term profits expected from almond production, the smaller will be the amount of removals. And the larger the total stock of almond orchards, the greater will be the amount of removals.

Data limitations necessitated some modifications of the California model in analyzing supply response for Spain. Only net additions (plantings - removals) to acreage are available. These net investments were modelled as a function of growers' expectations of revenues and costs, age distribution of the existing orchard stock, and variables to measure government subsidies to almond production. Two alternative statistical models are given in Table 3. The preferred model succeeded in explaining 81% of the variation in net almond investment in Spain from 1965-89. Figure 3 depicts actual vs. predicted net investment over this period based on this model.

In summary, the major findings from the supply analysis are as follows:

- Average yield in both California and Spain can be explained quite accurately by a statistical model that incorporates key weather, alternate bearing, and tree age distribution variables. These models enable preliminary crop forecasts based on average weather to be obtained up to a year in advance of harvest.
- California and Spanish acreage response decisions are based on perceived profitability of investments in almond orchards. The supply impact of reserve policy or other actions that affect profits in almond production can be estimated using the plantings and removals models summarized in this section.
- California and Spanish producers respond to similar economic forces. Both tend to expand acreage when prices increase or costs decrease and to decrease investment when profit potential decreases. This similarity of economic behavior is important for California producers to consider in their decision making. Actions taken by California producers to raise almond prices will encourage increased production by international competitors when these higher prices are transmitted to international markets.

II. Demand for Almonds in Major Consuming Countries

The almond industry has been faced with changing demand relationships. U.S. almond consumption has grown steadily from 37,500 tons annually in the early 1970s to over 100,000 tons currently, and it remains the largest single market for California almonds. Exports, however, have grown faster than domestic demand. Major markets for California almonds have developed in Japan and the EC countries of Germany, France, the Netherlands, and the United Kingdom. Essentially all almonds consumed in Japan are supplied by California, but the largest single export market for California almonds is Germany. Germany now accounts for close to 30% of total California almond exports, and since 1980 California has supplied 70% of the German almond market. France, where California enjoys a 58.5% market share, is the third largest California export market, followed by the Netherlands (56.8% share), and Great Britain (81.7% share). Italy, formerly the world's leading almond producer, now imports more almonds than Great Britain but is a comparatively minor market for California, which has a 25.7% share of the market. Other export markets for California almonds included in this study are in order of current importance as follows: Canada, Switzerland, Sweden, Belgium, Denmark, Australia, Austria, and Norway.

Our statistical models of almond demand in each of the major consuming countries assumed that per capita consumption of almonds was a function of (i) the price of almonds in that country, (ii) the price(s) of other competing nuts, and (iii) income in the country as measured by per capita consumption expenditures. For statistical purposes all monetary variables were deflated by each country's consumer price index.

For decision-making purposes the most important factor affecting the demand for almonds is the price charged. The relationship between price charged and quantity sold is quantified using the *price elasticity of demand*, which measures the percentage reduction in sales due to a one percent increase in price. The revenue impact of withholding almonds from the market through a reserve action hinges upon the resulting price response. If a given percentage reduction in sales causes price to rise by a correspondingly greater percentage, grower revenues will rise. When this relationship holds, demand is said to be *inelastic*.

Our analysis found that people buy more almonds as their purchasing power increases, but the magnitude of the income-consumption effect varied widely across countries. Filberts (hazelnuts) were found to be the only substitute good to significantly affect almond demand, and this effect, too, varied widely across countries.

The presence of foreign competitors means that California almond producers usually do not face the total demand for almonds in a country. Rather, California faces the demand that remains after taking account of foreign supplies. This *residual demand* is derived by subtracting the volume of outside supply from total demand at each price. We found that U.S. and Spanish almonds are very close substitutes in most consuming countries. Prices for Spanish and California almonds are highly correlated. For this reason we did not distinguish between California or Spanish almonds in our demand analysis. Rather, we estimated total almond demand in each of the major consuming countries. Residual demand for California almonds was then derived by adjusting total demand for the California share in each market.

The results of the demand analysis are summarized by country in Table 4. Efforts to estimate the statistical models of demand were quite successful. Two-thirds or more of the annual variation in almond demand was explained by the model in each case, and in most cases the explanatory power is in excess of 80% (see column 5 in Table 4). This high degree of explanatory power indicates a basis for confidence in the results.

The key result is that in most cases the price elasticities of residual demand are less than 1.0 in absolute value--residual demand facing California is inelastic (column 2). The California almond industry, operating through the ABC, affects the almond market by regulating the quantity of almonds on the market which, in turn, influences price. Inelastic demand means that a given percentage decrease in the volume of almonds placed on the market will induce a correspondingly *greater* increase in price. Thus, decreasing sales by withholding almonds from inelastic-demand markets will increase grower revenues because price rises proportionally higher than sales decrease.

The demand for almonds in the U.S. appears to be more elastic (sales respond relatively more to a price change) than demands among the major importers. The implication is that the California industry should consider allocating a greater proportion of its almonds domestically and restricting the amount of almonds intended for the export market, specifically Europe and Japan. This policy would raise prices in Europe and Japan relative to the U.S. and would also raise total industry revenues. Of course, higher prices in the European market would also represent a boon to the Spanish industry and would stimulate increased almond plantings in Spain.

As noted, the estimated magnitude of the *income elasticity* differs rather widely across countries, ranging from a high of near 2.0 (i.e., a 1.0% increase in income results in about a 2.0% increase in almond demand) for Japan and Italy to a low of 0.15 for Great Britain. In part, this variation may reflect the different uses to which almonds are put in the various countries.

Our analysis reveals a distinction between the European almond markets and almond markets elsewhere concerning the importance of filbert prices. Filberts were found to be the only nut to significantly affect total almond demand, but the filbert effect was found to be important only in European markets and, to some extent, in Canada. The European confectionery industry can replace almonds with filberts in many of its processes. In contrast, in the U.S., Japanese, and other nonEuropean markets, almonds apparently have no close substitutes, perhaps due to their greater use as a snack food in these markets and as a recognizable stand-alone ingredient, such as slivered almonds in cereals and on cakes, rather than as a ground-up, processed ingredient for marzipan and other confections.

The *cross-price elasticities* reported in column 4 of Table 4 measure the response of almond sales to a 1.0% increase in the filbert price. To illustrate, we estimated that a 1.0% increase in filbert prices in Germany would induce about a 0.25% increase in almond sales as, for example, food processors would replace some filberts with almonds in their recipes.

Together the models presented in Table 4 form a quite accurate representation of the bulk of the world demand for almonds. The 15 countries included here account annually for about 90 percent of the world's almond demand. A goodness-of-fit coefficient calculated between actual demands in these countries and their estimated values from our statistical models for 1970-89 indicates that our models capture in excess of 90% of the variation in almond demand among these countries during this period. Figure 4 plots the full volume of world transactions in almonds over this period, along with actual sales and predicted sales from our statistical models for the 15 major consuming countries.

The major implications of the demand analysis can be summarized:

- Inelastic demand for California almonds in export markets suggests that the industry can raise prices and profits in the short run by restricting the flow of almonds to these markets. Pursuit of this policy can be expected to lead to gradual erosion of the

California almond industry's share of the world market, as competitors respond to higher prices with increased rates of almond plantings. The balancing of this short-run, long-run tradeoff is discussed in some detail in the next section.

- Price elasticity of demand differences among major consuming countries can be exploited by restricting flows of almonds to countries with less elastic demands. Where resale of almonds among countries is easy, this strategy will be unsuccessful.
- Promotional campaigns for California almonds in general need not focus on positioning almonds relative to other nut products, because these nuts do not appear to be good substitutes for almonds. Filberts in Europe are the important exception to this rule.

III. Simulation Models of the California Almond Industry

Industry simulation models work by uniting demand and supply functions with market equilibrium conditions. In the case of the almond industry, the basic market equilibrium condition involves equating world supplies and world demand, where world supply is comprised of California, Spanish, and rest-of-world (ROW) supply, and world demand consists of the demands for consumption of almonds discussed in section II as well as the demand for almonds as stocks to carry-over into the next year.

The demand and supply models were integrated into two policy simulation models for the California almond industry. The first model, denoted as model 1, is a detailed, disaggregated model of the industry. It is intended for forecasting, general policy analysis, and simulation of the short-term impacts of reserve strategies. A second model, model 2, was developed for use especially in the area of reserve policy. Model 2 is an optimization model. It enables the user to solve for an optimal time path of reserve policies, taking into account investment response by foreign and domestic producers, given a specified set of market conditions. Both models and their statistical validation are discussed in this section.

Model 1: Figure 5 provides a schematic depiction of model 1. The available harvest is determined in any given year by the product of bearing acreage and average yield for each of the U.S., Spain, and the rest-of-the world (ROW). Harvest plus stocks carried in from the previous year represent the available supply. This supply interacts with demands in the various consuming markets to determine the California farm price for almonds. Foreign prices in the model are determined from the California grower price by adjusting the California price for marketing and transportation costs and exchange rates. This interaction is depicted in the lower half of Figure 5.

The model also takes into account the role of stockholding. Growers and handlers of almonds carry-over stocks from year to year for two reasons: inventory, and speculation that future prices will justify the costs of carrying stock forward. The inventory demand for stocks reflects the importance, especially among major handlers, of having a supply of commodity available at all times to meet the needs of important customers. This demand is relatively stable over time. Speculative demand, however, hinges importantly upon market conditions. Carrying forward stocks is profitable if the expected future price exceeds the current price plus storage costs including interest.

Perhaps because of its speculative nature, equations to explain and predict storage decisions are difficult to estimate statistically. A key factor affecting almond storage profits is year-to-year variations in yield due to the alternate bearing effect. We estimated an equation to predict annual carry-out of stocks as a function of yield of the *forthcoming* harvest, the change in yield from the past and forthcoming harvest, and a time trend. (Yield of the forthcoming harvest was used because, by the time final storage decisions are made, June 30 for Almond Board reporting purposes, decision makers have an accurate indication of the upcoming harvest.) This model succeeded in explaining 77% of the 1972-91 variation in the highly volatile almond storage series as illustrated in Figure 6. Storage functions nonetheless are the "weak link" in this type of simulation model. Therefore, model 1 is computer coded to enable users to input their own numerical estimate of carry-out stocks as an alternative to generating them through the estimated storage function.

The top half of Figure 5 depicts the way in which current year profits influence California plantings and removal decisions through the supply response models and in this manner determine future harvests. The interaction between current prices and profits and future supplies represents the key dynamic linkage in the simulation models. Because model 1 is intended primarily for short-term policy simulations, Spanish supply is generated external to the model; the user can input whatever values for Spanish supply are considered appropriate.

<u>Model 2</u>: Model 2 is designed specifically for analysis of reserve policy. Given California and Spanish supply conditions and a set of present and projected future demand

functions, the model chooses the time path of reserve policies that maximizes returns to the current group of California almond growers, taking into account that reserve-induced profits will stimulate additional plantings. Alternatively, model 2 will compute the revenue and other impacts of specific paths of reserve policies chosen by the user.

Figure 7 provides a flow diagram of the structure of model 2. Key features distinguishing model 2 from model 1 are that (i) demands are aggregated into two groups: domestic (U.S. and Canada) and exports to the rest of the world (ROW), (ii) a conceptual procedure is employed to decompose supply response in California between current California almond growers, and new entrants to the California almond industry, (iii) Spanish supply response is determined internally within the model, and (iv) no attempt is made to predict year-to-year changes in carry-out.

The first feature again enables the industry, as in model 1, to simulate the impact of a price discrimination strategy. The Japanese and European markets are not separated in model 2 to facilitate solution of the optimization problem. Thus, model 2 allows the industry to designate portions of a given year's California harvest to (i) the domestic market, (ii) the export market, or (iii) an allocated reserve.

The second and third distinguishing features enable the industry to simulate the amount of California sales that will be lost to California entrants and Spanish growers under reserve policies that raise prices and profits. As Figure 7 illustrates, profits from California almond sales in the domestic and ROW markets determine revenues and profits to California almond growers. These, in turn stimulate plantings and removals decisions based upon the supply response models discussed earlier in this report. Spanish net investment in almond orchards is determined similarly from prices generated in the ROW market. In choosing the optimal reserve path, model 2 specifically takes these competing supply responses into account.

The absence of a function to predict storage is a consequence of model 2's long-run character. Because model 2 is designed to calculate long-run profit maximizing reserve policies for the industry, year-to-year variations in storage can be expected to average out, and exclusion of a storage function from the model is equivalent to assuming a constant, equilibrium year-to-year carry-out.

Validation of the policy models: Validation of a simulation model involves testing the accuracy of the model's predictions. Validation indicates to decision makers the degree of confidence they should have in the model. To illustrate the model validation procedure, let P_t be the grower price predicted by model 1 for period t and let a_t be the actual grower price for this period. A measure of the forecast error is simply $E_t = P_t - a_t$. A cumulative measure of the error over several forecast periods is just the sum of the E_t. However, because negative and positive E_t will tend to cancel, it is useful to square the E_t before summing. This statistic, E_t^2, summed over the number of predictions and divided by the number of predictions is called the prediction *mean square error (MSE)*. It is clearly dependent upon how units are measured (e.g., whether price is in dollars or cents). Thus, statisticians usually scale mean square error so that it lies between 0 and 1.0, where a value of zero denotes a perfect forecast and a value of 1.0 denotes a forecast with no predictive power. This statistic is called *Thiel's inequality coefficient (TIE)*.

Table 5 presents within-sample validation results for the demand models in the largest consuming countries, California plantings and removals models, and the model 1 simulation model. (Because model 2 uses the same basic demand and supply structure as model 1, separate validation exercises for model 2 were not performed.) The results indicate strong predictive power. In all cases the TIE statistics are less than 0.10. Most important are validation results for the simulation model, which show the model's high degree of accuracy in within-sample predicting of world demand, real California farm price, and California harvests, plantings, and removals. Figure 8 plots actual California farm-gate almond prices vs. prices predicted from the simulation model for the period from 1970-89.

IV. Applications of the Models

Short-term forecasting: The number of acres bearing almonds in California in any year can be estimated accurately based on previous bearing acreage plus plantings four years prior less estimated current removals. Therefore, harvest forecasts hinge principally upon forecasts of yield. Once a harvest forecast is in place, it is combined with an estimate of carry-out from the prior year to obtain a forecast of the available supply of California almonds.

Price is determined next by equating the California supply plus estimated competitor supply with demand, both for consumption and for carry-over into the next year. Industry revenue is then forecast simply as the product of the predicted price and estimated equilibrium

California sales. The price and revenue impacts of alternative reserve policies are forecast by repeating the process, holding designated percentages of the California supply as reserve.

We illustrate the forecasting process with information for the 1993-94 crop year. Bearing acreage is estimated at 360,000, which is decomposed for purposes of the yield model into young-bearing, mature-bearing, and old-bearing acreage. A preliminary forecast of the 1993 crop could have been made from the statistical model in summer 1992, once 1992 crop yields were known or accurately estimable. Actual February 1993 rainfall would, of course, have been unknown at this time, so average rainfall for this period would be used instead. Our yield model would have predicted a 1993 crop of 512.5 million lbs., given this information.

The impact of systematically higher or lower than average rainfall could also have been predicted at this time, thus producing a *confidence bound* around the forecast. For example, actual February rain in the Chico, Fresno, and Modesto areas will fall within one *standard deviation* of its average about 68% of the time. Inserting these higher and lower amounts of rainfall into the yield model would have allowed us to say that with probability 2/3 the 1993 California almond harvest would be between 477.5-547.5 million lbs. Preliminary price and revenue forecasts could have been made at this point.

Once February 1993 rainfall was known in early March, a revised statistical forecast of the 1993 crop could be made. This forecast is 474.9 million lbs. By comparison the CASS subjective forecast, released on June 10, was for a harvest of 520 million lbs. The CASS objective forecast released on July 1 was, however, 470 million lbs., almost identical to the statistical model forecast that was available 3-4 months sooner.

Next, to forecast the 1993 grower price, we add to the 470 million lb. California harvest forecast an estimated 20 million lb. carry-in from the 1992 California crop and an estimated 55 million lbs. of net exports from Spain. The estimated carryout refers to uncommitted inventory, representing conditions of "stockout." Finally, we subtract an estimated 20 million lb. carry-out from the 1993 crop to obtain a forecast of the total amount of almonds available on the world market. The 1992 carry-out estimate is based on industry information and is presumably quite accurate. The 1993 carry-out is an educated guess, given the likelihood of a small 1993 crop, high 1993 prices, and a larger 1994 harvest. An alternative to this subjective forecast of carry-out would have been to use the statistical model of storage discussed earlier in this report.

Similarly, exports from Spain are based on a subjective forecast. The forecast amount is roughly equivalent to Spanish exports in 1987 and 1989. Recent years' exports have been lower, so a recovery may be in store. Alternatively, Spanish exports can be forecast using our statistical model of Spanish yield (Table 1) to forecast the Spanish harvest and then making guesses as to Spanish carry-out and carry-in.

Based on this information, model 1 forecasts a 1993 average grower price of $2.02/lb. A slightly higher harvest of 475 million lbs. leads to a price forecast of $1.98/lb. We can now use this information to produce a preliminary forecast for the 1994 crop. To begin, we set removals to 0 due to the high current prices. The forecast of the 1994 harvest is 603.8 million lbs., given mean rainfall. Adding or subtracting 36 million lbs. to this figure gives the 2/3 confidence band. The statistical storage model predicts that 113 million lbs. of this large crop would be carried over into 1995. Combining this information with the 20 million lb. guess of 1993 carry-out and 55 million lbs. in Spanish exports, yields a forecast average grower price of $1.79 for 1994.

Price forecasts at the bounds of our 2/3 confidence band for the 1994 harvest are $1.66 for a 640 million lb. crop (carry-out increasing to 131 million lbs.), and $1.91 for a 568 million lb. crop (carry-out decreasing to 94.7 million lbs.). Notice that these price changes for alternative crop sizes also illustrate the effects of reserve policy. For example, in the event of a 603.8 million lb. harvest, model 1 predicts that the industry could achieve a grower price of $1.79 in 1994 by diverting 17.5 million lbs. to reserve. This calculation assumes that 113 million lbs. of the harvest would continue to be carried over at the higher price. If carry-over decreased in response to the higher reserve-induced price as might be expected, the amount committed to reserve would have to increase accordingly to attain the $1.91 price objective. To the extent higher reserves decrease carry-out, they improve price prospects for the next marketing year.

<u>General policy analysis</u>: The boxes in Figure 5 enclosed with dashed lines depict external factors that influence the almond market but are not influenced in any important way by the almond market. These boxes are the key to conducting policy analysis with model 1. Given a set of current and projected future values for (i) foreign exchange rates, (ii) filbert prices and incomes in key consuming countries, (iii) external determinants of net present value and annual

profits from almond production such as tax rules and production costs, and (iv) February rainfall, a stream of predicted current and future outputs, prices, and revenues for almonds is generated by the model. To predict how changes in any of these external factors will affect the industry, the simulation model is run using the new value for the external factor, holding other external factors at their original value.

We illustrate this type of analysis with some examples:

- **A change in the tax status of investments in almond orchards.** There is no immediate impact on prices or production. However, profits and net present value from almond production are affected. This effect will lead, through the plantings and removals models, to changes in bearing acreage and, hence, future harvests and prices.

- **A change in water availability and cost.** The model would have to be modified to handle water rationing, but the effect of higher water prices is easily simulated. The process is similar to that for a tax change. Higher water prices reduce the value of almond investments, increasing removals and decreasing plantings. Lower harvests and higher prices follow.

- **Analysis of promotional campaigns.** Our models do not simulate directly the effects of promotional campaigns on demand but can be useful nonetheless in evaluating alternative promotional strategies. Consider a plan to spend $5 million on promotion in Germany. Given the structure of German demand, it is easy to estimate how much demand growth is needed to make the campaign pay off. Decision makers can then evaluate whether the necessary demand growth is likely to occur from the promotional campaign.

- **Evaluation of production research.** Production research can lower costs through improved technologies for maintaining and harvesting orchards or by developing higher yielding varieties of stock. Model 1 can simulate some of the short- and long-term consequences of research advancements. Cost-reducing technologies increase short-term profits, which will stimulate more plantings, eventually offsetting the higher profits. Perhaps paradoxically, introduction of higher yielding varieties may not raise profits even in the short run; because demand is inelastic in model 1, higher levels of production lead to lower revenue.

Analysis of reserve policies: The almond board has authority to invoke both allocated and nonallocated reserves. Allocated reserves divert almonds from primary consuming markets to secondary markets such as oils, animal feed, or disposal. Nonallocated reserves restrict the flow of almonds to market at specific points in time. A percentage of the crop may be withheld at harvest and released at intervals over the marketing season, or it may be withheld over the entire season and released into the next crop year.

Our analysis of reserve policy focuses on allocated reserve strategies. Nonallocated reserve policy is not studied in detail for two reasons. First, the demand, supply response, yield, and storage equations that comprise the simulation models are based on annual data. The unit of observation is the crop year. The models are not equipped to handle intra-year storage decisions.

Second, although the model can simulate the impact of inter-year storage decisions, our opinion is that the private market has incentives to undertake the optimal amount of both intra- and inter-year storage of almonds. To elaborate briefly on this point, storage from time t_1 to time t_2 is profitable if the expected increase in price from t_1 to t_2 exceeds the physical storage costs plus interest costs of holding almonds for this period. However, if storage is profitable to undertake, private traders and handlers have proper incentives to undertake the correct amount of storage independent of mandates from the almond board. Thus, we believe these decisions are best left to market forces and focus our analysis on allocated reserve policy.

Model 1 can be used to simulate specific allocated reserve strategies of interest to the industry. The present configuration of the model simulates the impacts of two alternative baseline policies, no reserve, and a reserve that maximizes industry profits for each year. The model can easily be programmed to consider other reserve strategies.

These simulations incorporate the world demand models and U.S. supply conditions discussed earlier in this report. They also incorporate conditions facing the industry at the present time, 1993, for factors such as production costs, income in consuming countries, etc, and reasonable projected growth rates over time for these factors. In this sense, the simulations should provide a reasonable indication of outcomes under the reserve scenarios posited. However, as simulations are carried further into the future, the results become increasingly speculative and are useful primarily in indicating the logical outcome from pursuing certain policies, not as outcomes that are expected to actually occur.

Table 6 reports results for selected years of a 20-year no-reserve-policy simulation. Under the no-reserve simulation, each year's available supply is placed on the market and is free to move to various consuming countries or into carry-over for the next year. Almond industry records indicate that a high rate of plantings, on average about 10,000 acres per year has occurred from the 1988-92 period. These plantings are beginning to bear as the industry enters the mid 1990s. Table 6 forecasts a rather rapid increase in California bearing acreage through 1995. In turn, under a no reserve scenario, the farm-gate price reported in *real* dollar terms (deflated to 1985 prices) is projected to fall from $1.18 in 1993 to $0.81 in 1995. The model forecasts further price declines through the remainder of the 1990s, which eventually begin to stimulate significant removals of acreage. As bearing acreage declines, price begins to recover after the year 2000, reaching a projected $1.76 in 2010. This price is sufficient to generate a new wave of plantings.

Note that the extremely low price projected in the year 2000 is not realistic. Diversions of product to secondary markets (almond butter, oils, feed) would occur even in the absence of a reserve to impose a price floor well above $0.13/lb. Nonetheless the no-reserve simulation illustrates potential problems faced by the industry in the next several years from expansion of bearing acreage. The industry faces the prospect of dealing with very large crops which, in the absence of a well-conceived reserve policy, auger periods of low and declining prices.

The no-reserve simulation also indicates a tendency for the industry to move in a cyclical fashion; high rates of planting in the recent past and near future promise to stimulate large crops and low prices. In turn, these conditions induce removals in excess of 10,000 acres per year from 2000-2007 in the simulation. Bearing acreage eventually drops below current levels, price rises, and a new wave of plantings begins.

The profit maximizing reserve allows the industry to distinguish among three markets for pricing purposes: (i) North America (U.S. and Canada), (ii) Europe, and (iii) Japan. This feature enables California to discriminate between foreign and domestic sales and exploit the relatively more inelastic foreign demands by restricting sales and raising price. This type of discrimination is authorized under the industry's marketing order. Remaining almonds after allocation to these three markets are disposed of in reserve.

In Europe, the model subtracts Spanish supply from the total demand and maximizes California profits with respect to the residual demand in each period. Any Japan-Europe price difference cannot, however, exceed the per-unit costs of shipping between the two locations because of arbitrage possibilities from the low- to high-price region. Thus, model 1 restricts price discrimination between Europe and Japan to be no greater than the per-unit transactions costs (estimated to presently be $0.23/lb.) of shipping between the two regions. This arbitrage constraint is binding in the simulation because Japanese demand is significantly less elastic than European demand, calling for a considerably higher Japanese price in the absence of the constraint.

Table 7 presents results for selected years of this 20-year simulation. Several features of the table are striking. To begin, the table suggests the magnitude of price differentials that logically emerge from discriminating against the inelastic-demand European and Japanese markets. The Europe-Japan price is roughly 2.5 times as large as the North America price. Again caution is called for in interpreting this result. The price differences that emerge logically from the profit-maximizing reserve scenario may not be realistic. They are based upon linear versions of the demand functions depicted in Table 4. However, prices in the ranges depicted for Europe and Japan have not been observed to date, so we have no knowledge whether indeed consumption would follow a linear relationship at these high prices.

Another striking result depicted in the table is the magnitude of the allocated reserve. Currently, the model projects that about one-third of the crop should be held off the market. Pursuit of a profit maximizing reserve in each year is, not surprisingly, projected to stimulate plantings and diminish removals. Bearing acreage increases continually throughout the simulation period. Projected growth in production exceeds projected growth in demand in this simulation. Thus, attainment of the profit maximizing reserve requires withholding progressively larger amounts of the crop in each year--nearly half the crop by the year 2010 according to the simulation.

Two key observations emerge from analysis of the profit maximizing reserve scenario: (1) California does have significant potential to raise average prices and profits through withholding almonds and discriminating against inelastic-demand markets. (2) Dogged pursuit of a static profit maximization strategy will lead to increased bearing acreage through increased plantings and decreased removals. Eventually, this supply response vitiates the effectiveness of reserve policy. The industry can withhold increasing amounts of almonds, but it becomes very expensive to do so in that production and disposal costs are incurred for reserve almonds and price to growers averaged across all production (sales + reserve) declines as production increases. A highly successful reserve policy is eventually its own undoing.

This observation is part of the inspiration behind model 2. Whereas the static profit maximizing reserve policy continues to maximize year-to-year profits despite knowing that such action will stimulate a countervailing planting response, model 2 is designed to take this effect into account in choosing an optimal reserve policy path. Raising short-term profits through reserve policy stimulates additional plantings from current California growers, California entrants, and foreign (Spanish) growers.

Spain, in particular, has the potential to benefit markedly from exercise of reserve policy by California producers for two reasons: First, profit-maximizing price discrimination strategies, if practiced, call for California to restrict sales and raise price in Europe, where most Spanish almonds are exported. Second, even though Spanish producers benefit from reserve-induced higher prices, they are not subject to the reserve and, thus, receive the higher price for their entire crop. Model 2 projects the magnitude of California and competitor supply response for any path of reserve policy chosen.

Table 8 illustrates the time path of a reserve policy that takes into account supply response by California almond producers and Spanish competitors. The simulation begins with current conditions facing the California and Spanish almond industries and assumes an annual 1.5% growth rate in world demand, a growth rate consistent with recent experience in the almond market. The model assumes that 36% of Spanish production (the average in recent years) enters the export market.

Model 2 allows almonds to be designated for sale in the domestic (U.S. and Canada) or export market or allocated to reserve. Reserve almonds are valued at $0.20/lb. in, for example, an almond butter program.

Model 2 maximizes discounted profits to the group of <u>current California almond producers</u> calculated over a 50 year horizon. Model 2 is specifically structured so as <u>not</u> to consider profits to entrants into California almond production in choosing the optimal reserve path. Once again, it is not reasonable to claim that accurate predictions as to industry behavior can be made 10 years into the future, let alone 50 years. The point of a 50 year horizon is to enable model 2 to take account explicitly of the trade off between current profits from exercise of reserve policy and offsetting future costs due to expansion of almond acreage.

Tables 7 and 8 provide an interesting comparison. The reserve policy that takes into account future supply response is much more moderate during the first 20 years of the 50-year horizon than is the single-period, profit-maximizing strategy over the same time. Only modest amounts are held in reserve during this time under the optimal long-term reserve strategy. Price discrimination against the export market occurs only after year 12 of the 50-year horizon, And only in the last years of the horizon does the magnitude of price discrimination approach the simple (year-to-year) profit maximizing amount of price discrimination.

Thus, model 2's optimal long-term reserve strategy prescription suggests that, in the early years of the strategy horizon, it is indeed optimal to moderate pursuit of profit maximization. Essentially, the model has two ways to moderate profits relative to the single-period profit maximizing allocation. It can hold too much or too little in reserve, and discriminate too much or too little against the export market. The actual choices made are instructive. First, the percentage of the crop held in reserve is lower in years 1-20 than suggested by Table 7's static profit maximization strategy. Second, the optimization model elects not to discriminate against the export market until year 13 and instead actually dumps commodity abroad in early years of the horizon, as reflected in lower export market prices through year 12. The effect is to depress the export price, creating disincentives to invest in additional orchards in Spain especially but also in California. The simulation projects net removals of Spanish almond orchards through year 19 under this policy.

Eventually, however, model 2's long-run optimal reserve policy begins to resemble the year-to-year profit maximization strategy of model 1. Reserves reach 1/3 of the crop by year 28 and approach 1/2 of the crop during the final years of the horizon. Similarly the extent of price discrimination against the export market becomes pronounced, but approaches the simple year-to-year profit maximum only in the last periods of the 50-year horizon.

Despite moderating profits in the early years of the horizon, the optimal strategy eventually permits a considerable expansion of acreage and production of almonds. As indicated in Table 8, as the 50-year horizon plays out, increasing amounts of this expansion are projected to come from new California entrants.

The key point of the long-run optimization analysis for purposes of California almond industry policy is that the optimal long-term reserve strategy involves moderation of the single-year profit-maximizing reserve strategy. Yet the optimal policy is not no reserve policy at all.

In each year, the model 2 prescription involves some combination of reserve and/or price discrimination.

The model chooses not to maximize single-year profits in the course of maximizing discounted profits over 50 years because putting the brakes on profit maximization diminishes entry and makes it easier to earn profits in later periods. During later years of the 50-year horizon, the future becomes less important, and the optimal policy increasingly comes to resemble the year-to-year profit maximization strategy detailed in Table 7.

The reserve policies simulated here are only illustrative of the range of policies that can be analyzed with the simulation models. Both the Table 7 and Table 8 results are based upon a set of external factors that reflect present conditions and reasonable projected changes. However, different values for these external factors, such as rates of demand growth, will produce different prescriptions for reserve policy, and it is important for industry decision makers to discuss the range of values they consider reasonable for these factors.

The profit consequences of alternatives to the optimal policies can also be estimated. For example, there may be several good reasons not to discriminate fully against the European and/or Japanese export markets. By inputing into either model 1 or model 2 specifc reserve policies of interest to the industry, the outcomes of these policies can be estimated and compared to the outcomes suggested by the short- and long-run optimal policies (models 1 and 2, respectively). When utilized in this fashion, models 1 and 2 become useful inputs into, not replacements for, industry decision making.

Table 1

Spanish Almond Yield Models
(dependent variable is average yield, in shell kg. per hectare)

explanatory variables	total area	dryland area	irrigated area
	--estimated coefficients--		
constant	781.68	761.98	1633.2
Yield in the prior period	-0.36	-0.51	- 0.40
Time trend	-4.81	-9.63	33.84
January-February rainfall	-1.66	-1.33	-4.61
February frost	-52.40	-37.40	-166.26
March-April rainfall	1.27	1.18	2.69
July rainfall	3.08	2.62	19.78
$R^2_{adj.}$	0.74	0.75	0.42

Table 2. Expected Net Present Values and Discount Rates

Year	NPV	r
1961	4412.03	-0.00167
1962	6217.99	0.002246
1963	4704.03	0.000586
1964	5594.45	0.001477
1965	4997.99	0.001766
1966	5039.12	0.000097
1967	5889.79	-0.00572
1968	6110.70	-0.00400
1969	1294.39	-0.00675
1970	2114.79	-0.01183
1971	2464.04	-0.02149
1972	7200.58	-0.02845
1973	28573.34	-0.02595
1974	11043.47	-0.02552
1975	3896.13	-0.03533
1976	3801.31	-0.05067
1977	11818.40	-0.05113
1978	25518.37	-0.04424
1979	22759.59	-0.03887
1980	14175.54	-0.03327
1981	-6515.63	-0.02756
1982	-4328.58	-0.02125
1983	-3157.73	-0.02895
1984	-5758.06	0.004244
1985	-4681.26	0.011991
1986	9601.44	0.012442
1987	44.95	0.020684
1988	188.69	0.021373
1989	-5022.44	0.016840
1990	-6011.78	0.012490

NPV is the expected net present value (in 1977 dollars) of an acre of almonds planted in the given year, assuming all prices and costs remain constant in real dollars for the life of the orchard. The discount rate r is the after-tax return on 30 year bonds minus the expected inflation rate. Expected inflation is the weighted average of the past four year's increase in the GNP deflator with declining weights of 0.4, 0.3,. 0.2, and 0.1.

Table 3

Area Response Models of Spanish Almond Industry, 1965-1989

(dependent variable is thousands of net hectares of investment in almond orchards)

Explanatory Variables	(1)	(2)
	--estimated coefficients--	
Constant	-97.12	8898.00
P_t	17.06	8.16
C_t	0.126	-0.45
OB_t	0.55	-
MB_t	–	-0.17
D70	15.95	-
D72	56.40	37.79
T	-	4.53
$R^2_{adj.}$	0.81	0.83

Variable definitions

P_t = expected price computed as average of past 2 year's prices
C_t = expected cost computed as the General Farm Price Index for Spain
OB_t = stock of old bearing trees over 34 years of age
MB_t = stock of mature bearing trees aged 11-34 years of age
D70 = dummy variable denoting government subsidies to almond orchard development for the period 1969-79, excluding 1972
D72 = dummy variable to denote extremely high 1972 plantings
T = time trend

Table 4

Demand Analysis Results For Major Almond Consuming Countries

Country	Price elasticity: total demand (1)	Price elasticity: residual demand (2)	Income elasticity (3)	Cross product effect[a] (4)	Adj R^2 (5)
U.S.	-1.076	-1.076	0.999		0.90
Germany	-0.487	-0.700	1.316	0.252	0.95
Netherlands	-0.622	-1.095	0.338	0.356	0.88
France	-0.406	-0.694	0.290	0.153	0.87
G. Britain	-0.523	-0.640	0.152		0.75
Italy	-0.184	-0.716	2.053	-2.147	0.85
Japan	-0.431	-0.431	1.849		0.96
Canada	-1.000	-1.278	1.209		0.85
Switzerland	-0.381	-0.682	0.300	0.186	0.88
Sweden[b]	-0.570	-0.753	0.170		0.66
Belgium	-0.388	-0.737	0.459		0.84
Denmark[b]	-0.230	-0.351	1.630	0.120	0.91
Australia[b]	-0.230	-0.502	0.600	0.140	0.91
Austria	-1.137	-7.259	0.452		0.87
Norway	-0.358	-0.373	0.641	0.198	0.92

[a]Elasticity of almond demand with respect to filbert price for all countries except Italy, where cross product effect is the elasticity of almond demand with respect to Italian almond harvest.
[b]Indicates that estimates are from a linear model. Otherwise, models were double log.

Table 5
Almond Model Historical Validation Statistics

	Estimation Period	RMSE	TIE
Historical Validation For Demand Equations: Double-Log Specification			
USA	1961-89	0.123	0.016
JPN	1962-89	0.031	0.014
CAN	1961-89	1131.280	0.012
GBR	1970-89	0.033	0.011
DEU	1970-89	0.059	0.005
NLD	1961-89	0.049	0.006
FRA	1970-89	0.029	0.005
ITA-imp	1961-89	0.066	0.037
ITA-exp	1961-89	0.169	0.021
Historical Validation For Supply Equations			
USA Planting	1962-90	4.273	0.023
USA Removal	1962-90	2208.609	0.037
Historical Validation For Simulation Model			
World Demand	1970-89	52490.030	0.014
US Real F.G. Price	1970-89	0.319	0.029
US Harvest	1970-89	90311.390	0.025
US Planting	1970-89	8571.284	0.047
US Removal	1970-89	3970.520	0.068

Table 6

Simulated Almond Price, Plantings, Removals and Bearing Acreage: No Reserve Policy

Year	Farm price ($)	Plantings (acres)	Removals (acres)	Bearing acreage
1993	1.18	14,453	2,223	384,705
1994	0.97	11,738	78	393,857
1995	0.81	8,971	0	401,178
2000	0.13	0	11,528	426,115
2005	0.80	0	18,016	350,112
2010	1.76	6,558	370	308,627

Table 7

Simulated Almond Prices, Plantings, Removals and Bearing Acreage:

Profit Maximization Reserve Policy

Year	N.A. Price ($)	Eur Price ($)	Japan price ($)	N.A %	Eur %	Jpn %	Res %	Plant (000 ac.)	Remove (000 ac.)	BA (000 ac.)
1993	1.25	3.09	3.31	39.2	22.8	4.8	33.2	13.9	3.6	365
1994	1.25	3.09	3.32	37.8	21.7	4.5	35.9	15.5	1.1	373
1995	1.25	3.09	3.32	40.5	23.1	4.8	31.5	15.7	0	381
2000	1.25	3.10	3.33	35.4	19.4	4.0	41.2	12.5	0	488
2005	1.26	3.11	3.34	33.5	17.5	3.6	45.3	8.5	0	576
2010	1.26	3.13	3.35	32.0	16.1	3.3	48.6	6.9	0	626

Table 8

Selected Results for Optimal Reserve Policy Model

year	Dom %	Exp %	Res %	CA profits /acre[a]	U.S. price[a]	Export price[a]	CA prod[b]	Ent prod[b]	Span exp[b]
1993	47	52	1	1,092	1.46	1.36	406	0	92
1994	42	57	1	926	1.58	1.13	405	0	92
1995	42	58	0	931	1.61	1.16	402	0	92
2000	40	60	0	911	1.63	1.09	416	27	89
2005	45	51	3	1,067	1.42	1.50	450	71	86
2010	47	42	10	1,052	1.24	1.91	495	136	82
2020	28	35	34	823	1.30	2.30	597	343	82
2030	29	25	46	683	1.33	2.56	652	616	89
2042	32	23	44	710	1.24	2.76	670	813	110

[a]Profits and prices measured in actual (nondiscounted, nondeflated) dollar amounts.
[b]Production measured in millions of lbs. kernel wt.

Figure 1
Plantings of California Almonds, Actual and Predicted

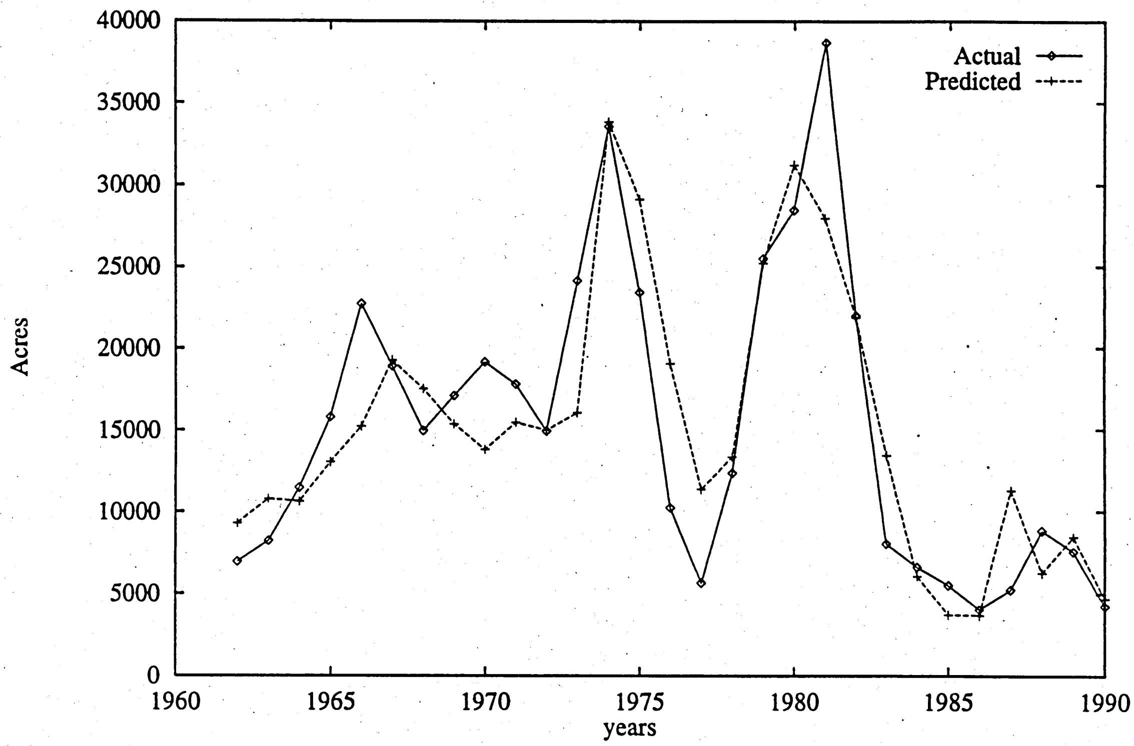


Figure 2
Removals of California Almonds, Actual and Predicted

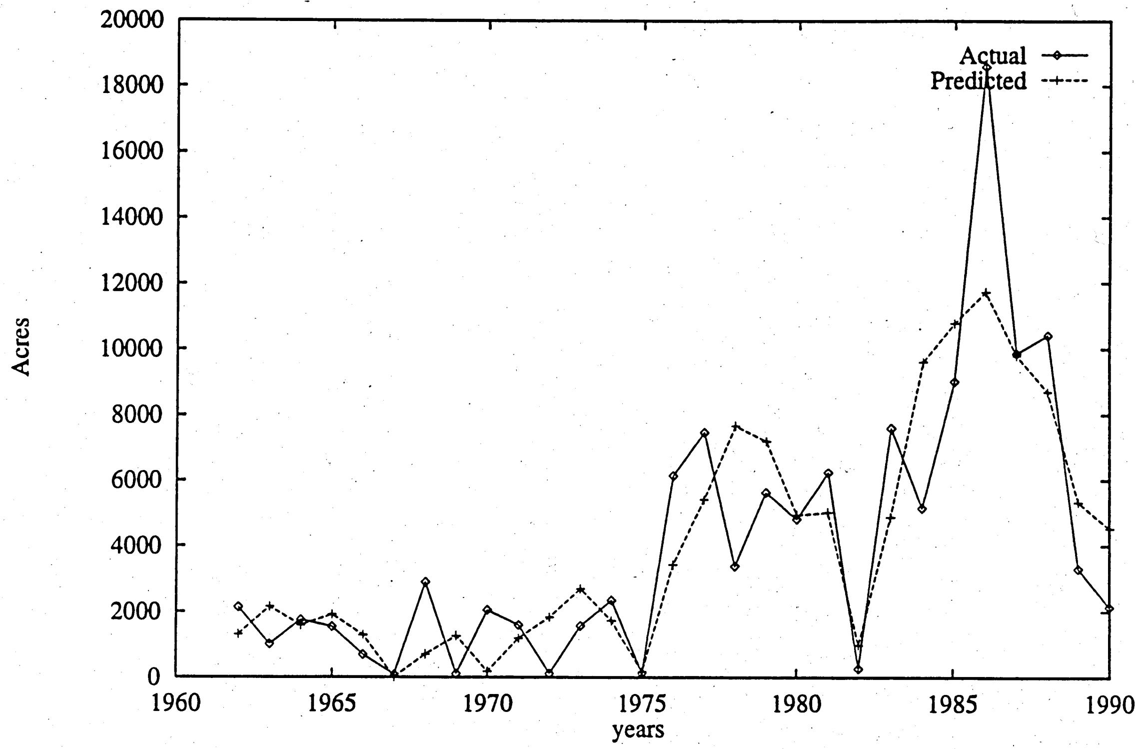


Figure 3
Changes in Total Spanish Almond Area, Actual and Predicted

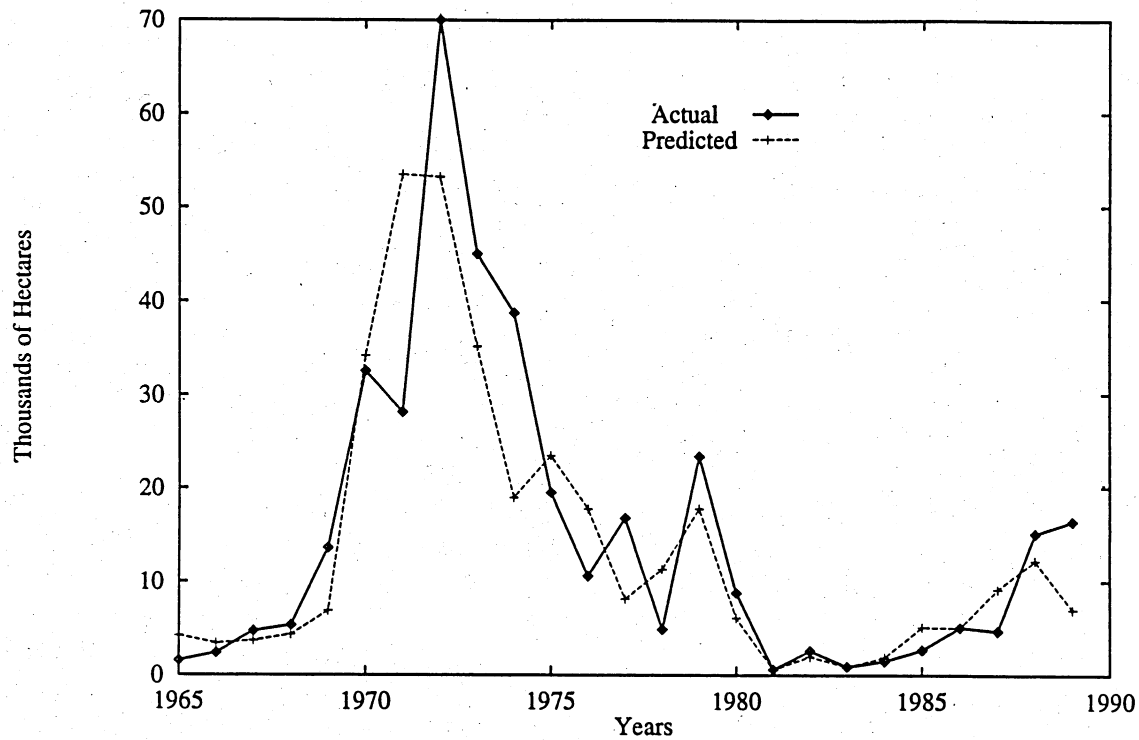


Figure 4
Actual and Fitted Values from Almond Net-Import Regressions, 15 Largest Markets, and Total World Purchases

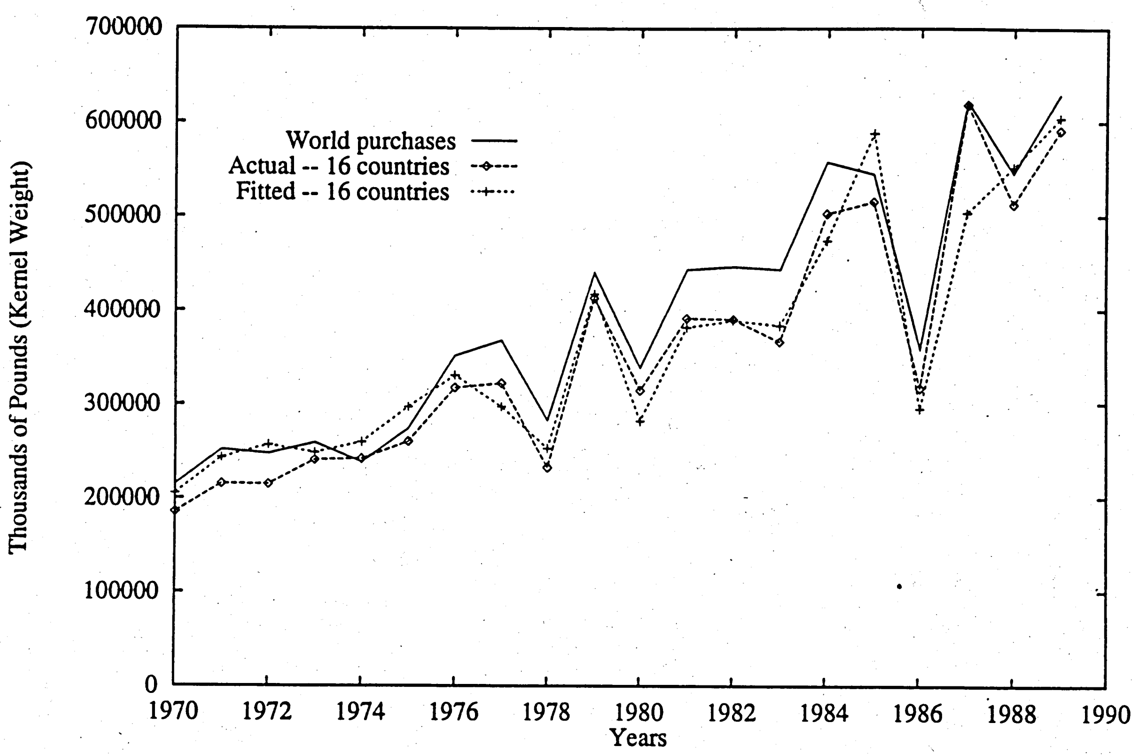


Figure 5
Flowchart for Model 1

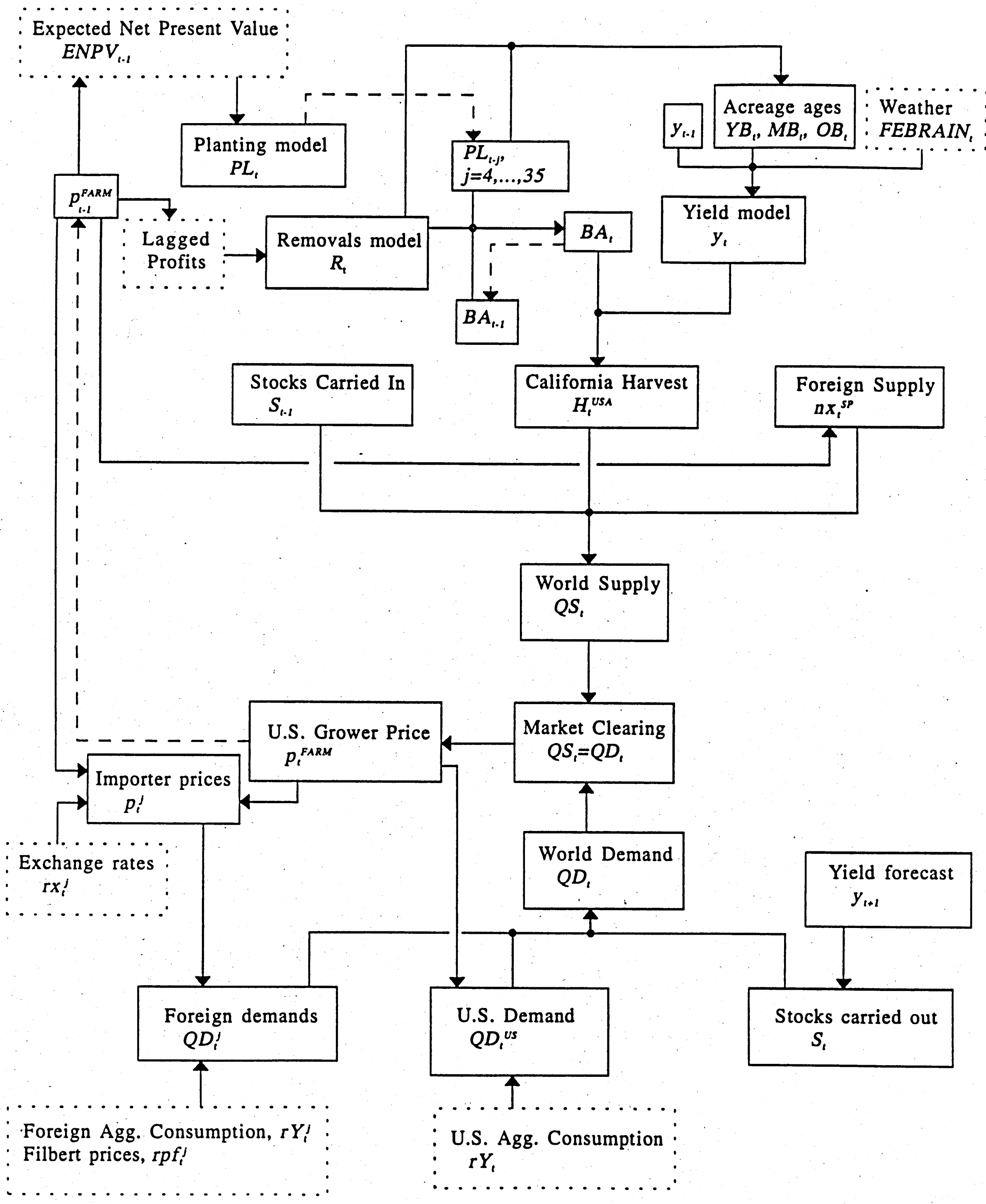


Figure 6
Uncommitted Inventories at End of June: Actual and Predicted

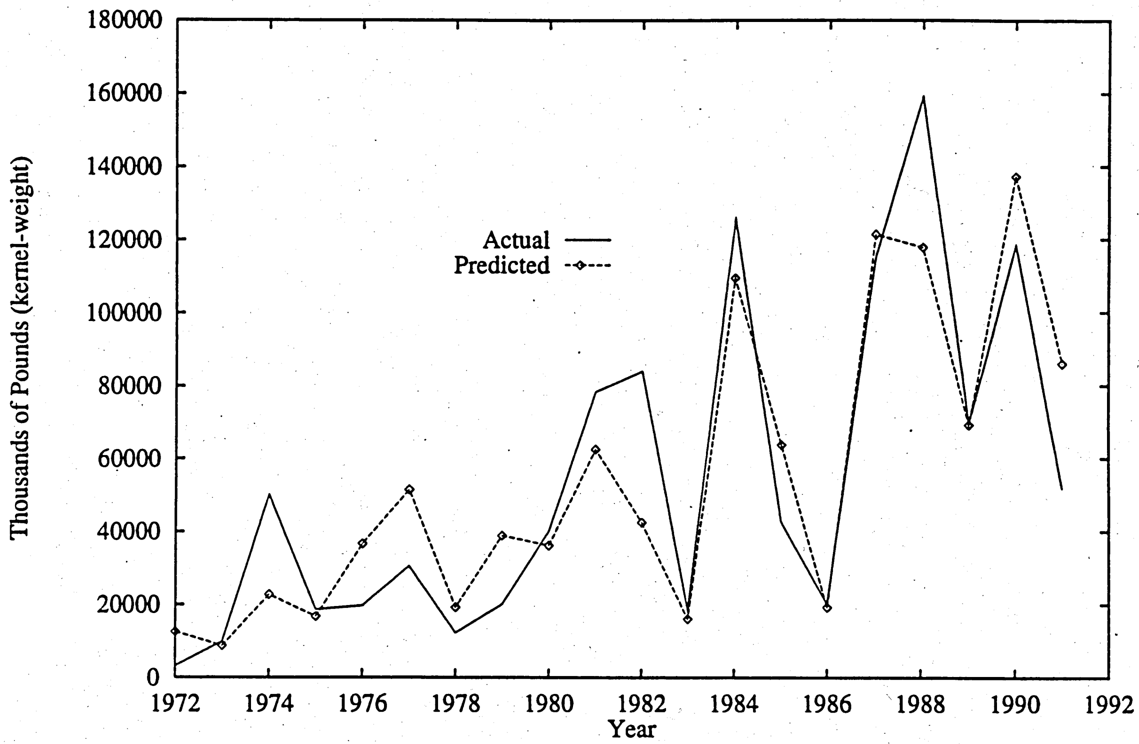
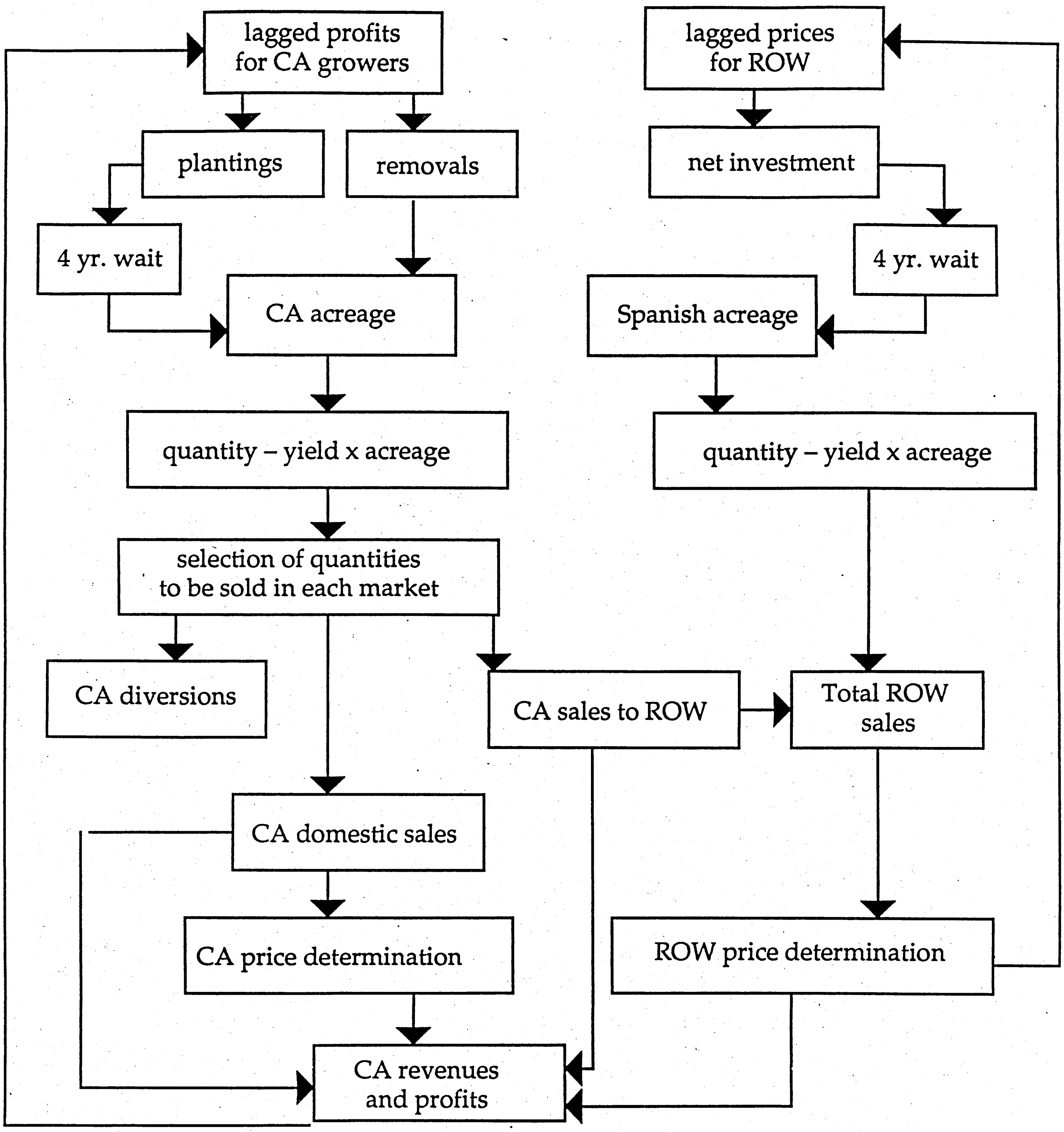


Figure 7

THE RESERVE POLICY OPTIMIZATION MODEL



Note: entrant and existing grower acreage and production are tracked separately within the model but do not effect the working of the model since new entrants immediately fall under the auspices of the ABC.

Figure 8
Real U.S. Farmgate Price, Actual and Predicted