Economic Impacts of Mandated Grading and Testing to Avoid a Negative Food Safety Event: Ex Ante Analysis of the Federal Marketing Order for Pistachios

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Short abstract

The California pistachio industry led an initiative to establish a federal marketing order, which mandates quality standards and an inspection program to assure food safety and consistency in the quality of California pistachios. We develop a stochastic dynamic simulation model of the pistachio market to investigate quantitatively the likely effects of such collective action enforced by government mandates. Simulation results indicate that, across the full range of parameters used in the analysis, the benefit-cost analysis was always favorable to the proposed policy. The measured benefits to producers, the nation, or the world always well exceeded the corresponding measure of costs, typically by many times.

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1. Introduction

The U.S. pistachio industry, which is located almost exclusively in California, has experienced phenomenal growth over the past thirty years. The value of U.S. production of pistachios grew from about zero in 1976 to $333 million in 2002. The U.S. share of the rapidly growing global pistachio industry has also increased. Outside California the main pistachio growing region is the Middle East, including Turkey and especially Iran.

In recent years, a group of California pistachio growers led an initiative to establish a federal marketing order that would mandate quality standards and an inspection program to assure consistency in the quality of California pistachios. The main provisions of the proposed marketing order set standards and require the testing for quality and aflatoxin, a cancer-causing mold found in many nuts and grains. Proponents argued that the marketing order would increase consumer confidence and reduce the chance of an aflatoxin event in the pistachio market, and thereby stimulate demand and enhance consumer benefits and producer returns. Hearings were held in 2002. In early 2004, the proposal was supported by more than 90 percent of growers voting, and the marketing order is expected to be established in 2004.

This paper includes background on the California pistachio industry and the food-safety issues, a discussion of the rationale for collective action in the form of a marketing order that led to the development of the marketing order. We then develop the dynamic stochastic simulation model and present results of the likely economic consequences of the pistachio marketing order.

2. The California Pistachio Industry

World production of pistachios has grown rapidly during the past 20 years, and U.S. production has increased as a share of that growing total[1]. Iran is still the largest producer, but the United States is established as the second-largest pistachio producer in the world, followed by Syria and Turkey, and is now the second-largest exporter after Iran.[2]

Almost all U.S. pistachios are produced in California.[3] California's production has grown more than 200-fold since 1976, when its first commercial crop of 1.5 million pounds was harvested. California produced a record crop of 302 million pounds in 2002, up from the previous record of approximately 242 million pounds in 2000.[4] The longer-term trends have shown steadily growing acreage, yields, quantity, and value of production, and corresponding downward trends in prices, with important fluctuations around those trends. We have also seen steady growth in California exports as a share of world trade, and California exports as a share of production.

Total California pistachio acreage grew from 34,726 total acres in 1980 to 106,000 total acres in 2002. Normally it takes a pistachio tree 7-8 years to mature before

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[1] Statistical information in this section was supplied by the California Pistachio Commission unless otherwise noted.

[2] Iran's exports peaked in 1996 when it exported 308 million pounds of pistachios, but fell to 127 million pounds in 1997, when Iranian pistachios were banned in the European Union because of aflatoxins. Iranian exports returned gradually to near pre-ban levels in the following few years.

[3] In 2000, Arizona had 2,700 acres and produced 4 million pounds of pistachios, just 1.5 percent of national production in that year (Arizona Agricultural Statistical Service, AASS), and too small to have significant impacts on the national market for pistachios. New Mexico had 391 acres of pistachios in 1999, less than half a percent of total acreage (New Mexico Agricultural Statistics, 2000).

[4] Pistachios exhibit alternate bearing with low yields tending to follow high yields, thus 2001 was a relatively low-yield, low-production year. The yield cycle is an important factor in quantity produced, price received, total value of the crop, and gross revenue per bearing acre (Risk Management Agency (RMA), USDA).

it produces an economically significant crop, and 12-15 years to reach full potential (CPC). Bearing acreage in 2002 was estimated by the California Agricultural Statistical Service (CASS) to be 83,000 acres, up 222 percent from 25,773 bearing acres in 1980. The growth in area and production has been steady for the past 22 years and is expected to continue, with non-bearing acreage having reached 23,000 acres in 2002 (CASS). The value of the crop varies with the quantity produced. The long-term trend is for increasing quantity, and increasing value of the crop, but falling returns per pound, reflecting the fact that supply has been growing faster than demand. The trend for the past 22 years in price per pound (even in nominal terms) has been gradually downward from the high in 1980 of $2.05 a pound to $1.11 per pound in 2002.

3. Food-Safety Issues and Aflatoxin in Pistachios

Aflatoxin is the main issue behind the marketing order for California pistachios. An event of aflatoxin poisoning in pistachios or some other product, or simply concern about the possibility of such an event, could have adverse effects on demand.[5]

Many produce-related food scares have occurred in recent years. For the period from 1990 to 1999, the Center for Science in the Public Interest (CSPI) lists 55 cases in the United States alone. Two recent produce-related events include cantaloupes and *Salmonella* in 2000, 2001 and 2002 (Food and Drug Administration, U.S. Department of Health and Human Services) as well as strawberries and cyclospora in 1996 (details can be found in Calvin, 2003. An earlier well-known event demonstrating the public's sensitivity towards food safety was the alar scare in apples in 1989 (Van Ravenswaay et

[5] Aflatoxicosis is poisoning that results from ingestion of aflatoxins in contaminated food or feed. In rich countries, aflatoxin contamination rarely occurs in foods at levels that cause acute aflatoxicosis in humans, but there have been important aflatoxin events in pistachios. (Information here is taken from http://vm.cfsan.fda.gov/~mow/chap41.html .)

al. 1991).[6] The main event that directly related to pistachios occurred in Europe. Iranian pistachio imports were banned in the European Union in September 1997 because shipments exceeded allowed levels of aflatoxins (European Commission, 1998).

4. Rationale for Collective Action in Pistachio Markets

Mandated collective action programs, such as the California Pistachio Commission and the proposed Federal marketing order for California pistachios, use the coercive powers of the state or federal government to oblige individual producers to participate and contribute assessments. The programs are voluntary in the sense that their establishment requires the support of a sufficiently large majority of producers, but they do not require unanimous support and consumers, who pay a portion of the costs, do not have voting rights. Even among producers, unlike truly voluntary collective action programs, such as cooperatives or clubs, once they have been established, these programs are mandatory for all producers of the commodity in the defined area.

The conventional in-principle economic justification for the use of the government's taxing and regulatory powers in this fashion is that there are collective goods within the industry – research, promotion, grade standards, packing regulations, public relations, and the like – that will be undersupplied otherwise. In practice, whether the pistachio marketing order will yield net benefits to producers, consumers, the state, and the nation as a whole, will depend on the nature and extent of "public good" or "external" costs and benefits associated with minimum quality standards and mandatory testing for aflatoxin, along with the other provisions of the order, and the costs of implementing the program.

[6] Additional studies of demand impact of food safety events and information on demand can be found in Smith, van Ravenswaay and Thompson (1988), Brown and Schrader (1991), Richards and Patterson (1999) and Piggot and Marsh (2004).

The regulations under the marketing order include various elements that have different types of public-good characteristics, some more easily justified than others. Standardized grades and packaging have a public good role in that they will reduce transaction costs (e.g., see Freebairn 1967, 1973). An argument for quality regulation can be made where quality is hidden and the market can be spoiled as a result of the distortions in incentives to provide and communicate information about quality (e.g., Akerlof 1970). The "public good" element is that when consumers experience the quality of pistachios from one supplier, this affects their subsequent demand for pistachios from other suppliers as well. Especially in the case of a food quality issue, a bad experience associated with any pistachios will likely affect the whole industry and the impacts can be large and long lasting, but individual producers will not take these industry-wide consequences of their actions entirely into account.

An industry-wide food safety issue could arise as a result of evidence of death or illness associated with consumption of pistachios containing aflatoxin. As with other food scares, there may be consequences for demand experienced throughout the industry, not just by the firms directly responsible for the incidents in question. The same type of market problem can arise even without a case of actual food poisoning. It could result from an actual aflatoxin event involving the discovery of aflatoxin in excess of the 20 parts per billion allowed by the Food and Drug Administration. Even in the absence of an aflatoxin event in pistachios, there may be adverse effects on the pistachio market from the perception of such a threat based on adverse publicity associating aflatoxin with pistachios, for some other reason, such as when excess amounts are discovered in other products in the United States or anywhere else in the world. Negative perceptions could result from adverse attention to aflatoxin even if no excess amounts were discovered. Negative consequences could result from negative perceptions among final consumers resulting in their choosing not to purchase products, negative perceptions among market middlemen such as retailers resulting in their choosing not to stock a product that might be subject to recall or lawsuits, or from governments choosing not to allow products to be sold because of heightened concerns over food safety.

Perceptions of a food quality problem are not specific to individual suppliers, but affect the industry in a collective way. Therefore, the private incentive to assure high quality nuts that are perceived as safe does not reflect the full, industry-wide or public benefit of these actions. In such cases, voluntary actions, motivated by private incentives will provide less safety and quality assurance than would be in the interest of the industry (and, perhaps, the general consuming public). In this case, all farms and firms would benefit from a stronger reputation for pistachios in general, but their own actions cannot assure such a reputation, unless the rest of the industry matches those actions. Individual farms and firms have the private incentive to keep their own direct costs low and invest less in safety testing and quality assurance than would be optimal from the view of the whole market, giving rise to a free-rider problem.

Two characteristics of the pistachio market make the public good concerns particularly important in the context of food safety assurances and quality standards. First, as with many fresh fruits and nuts, there is little brand identification with pistachios. Thus, a customer who has an unsatisfying experience with a purchase of pistachios or who hears negative news about the safety of consuming pistachios is unlikely to associate this with a specific brand or supplier. Unlike branded, packaged consumer items, any negative news would not just affect a specific supplier, but rather would affect the industry at large. Second, many pistachio purchasers consume the product infrequently, purchase relatively small quantities, and have relatively little knowledge about pistachios. One would therefore expect the industry-wide reaction to an aflatoxin event in pistachios to be large, compared with more familiar foods, especially in the context of food safety concerns. The wholesale trade would be even more sensitive to an event if a recall were necessary. Consequently, the pistachio industry has strong in-principle reasons for acting collectively to assure industry-wide compliance with quality and food safety standards. But this is only an in-principle case. Whether collective action of this type would provide net benefits to the industry depends also on how effective the program would be in reducing the likelihood of a food scare, or its severity, and on the costs of the program.

5. A Simulation Model of the Impacts of the Pistachio Marketing Order

The pistachio marketing order involves a cost borne in every year, aiming to reduce the odds and severity of a major negative shock to demand. The criterion here involves comparing the year-by-year costs with the expected benefits from the change in the odds and severity of an episodic major negative shock to demand. Consequently, rather than evaluate benefits and costs in a typical year, in the evaluation of the marketing order for California pistachios it is necessary to compare the expected values of costs and benefits over many years. Hence, our analysis of the costs and benefits of the proposed pistachio marketing order involves a stochastic dynamic simulation rather than the more typical comparative static analysis.

We simulate the markets for California pistachios and project production, prices, and allocation of pistachios for 50 years, beginning in the year 2000. Yields vary over time to reflect alternate bearing and random influences. Aflatoxin events also occur at random. In our model, both the probability of an event and severity of the demand response to a given event are lower with the marketing order in place. For each "draw" of a time series of future yields, we simulated the outcomes for economic variables in the industry with and without the marketing order in place. By considering 100 draws of future time paths of yields, we were able to estimate the effects of the marketing order on measures of interest, for average values and the range of outcomes (or other measures of variability).

We specified equations representing the domestic and export demands for pistachios, including storage demand, using estimates of elasticities and data on market shares, quantities and prices. The proposed marketing order applies solely to the domestic market. It imposes regulations, which entail costs of compliance with requirements for aflatoxin testing and meeting quality standards, borne in the first instance by processors, and other (relatively minor) costs to be financed by an assessment on processors. The potential increases in demand, on average, relative to a scenario without a marketing order include the effects of (1) a reduced probability of a negative shock to demand associated with an aflatoxin event and a reduction in the size of the negative shock associated with a given event, and (2) an increase in demand in every year owing to greater consumer confidence in the product and greater buyer confidence in the product associated with the USDA testing and certification.

Supply, Demand, Price and Market Allocation

The equations of the model are specified as linear forms, and they are parameterized using data on initial values of prices and quantities, assumptions about underlying proportional trends in demand and yield, and elasticities. The initial data on prices and quantities are the average actual values for 1997-2001, expressed in 2003 dollar terms, and these values do not vary across alternative simulations. In recognition of uncertainty about the values for the elasticities and trend growth rates, as well as a set of base values we try alternative values, and examine the implications for findings.[7]

Long and sad experience reveals that it is surprisingly difficult to estimate useful elasticities of supply or demand for agricultural products, and the precision and robustness of the estimates is often low. In this analysis, we place greater emphasis on introspection and calibration approaches rather than placing reliance on the direct use of econometrically estimated elasticities. This is because we seek to measure long-run responses of the type that generally cannot be estimated directly, especially for perennial crops, and we have in mind to simulate policy change that goes outside the range of past policy change. In addition, we are dealing with an industry that is comparatively young, and has been growing comparatively quickly, such that fewer than 25 years of annual time-series data are available, and it could not be argued that the structure has been stable over the period, or that the market has been in long-run equilibrium.

Models of supply response for perennial crops are reviewed in detail by Alston et al. (1995). The more theoretically defensible models partition the supply response into separate equations representing elements of yield per bearing acre and the number of

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[7] A number of studies have estimated supply and demand elasticities for elements of the fruit, nut, and vegetable sector. For instance, see Alston, et al. (1995, 1997, or 1998), or Huang (1985, 1993).

bearing acres (or other measures of the stock of bearing trees), with adjustments to bearing acreage reflecting removals of trees and plantings with a lag to reflect the time it takes for trees to mature and come into production. In the case of pistachios, the trees are comparatively long-lived, and, given the relatively young industry in California, removals for replacement are not expected to have a substantial impact on the stock of trees over the period of our analysis. We include in the model a fixed removal rate of 1 percent per year, which is consistent with recent history, and we increase this rate to 2 percent per year after 2015 to reflect increases in the average age of the bearing stock.

Based on a knowledge of the pistachio industry and the literature, we take a fairly conventional approach and assume that the only supply response to price changes in our analysis is through plantings. Specifically, plantings depend on the expected present value of revenue per acre over the life of the planting. The equation for plantings is specified such that

$$PL_t = a_0 + a_1 E_t\left(PV_t\right) \tag{1}$$

where PL_t is the area of plantings of pistachios made in the year t, PV_t is the present value in year t, over the life of the orchard, of gross revenue per acre for plantings made in the year t, E_t denotes expectations formed in year t and a_0 and a_1 are the parameters of the equation[8].

As a proxy for the expectations variable, in the absence of the marketing order, we use a five-year moving average of the value of revenue per acre. That is

$$E_t\left(PV_t\right) = \tfrac{1}{5}\sum_{n=0}^{4} R_{t-n} = \tfrac{1}{5}\sum_{n=0}^{4} P_{t-n} \times Y_{t-n} \tag{2}$$

[8] The linear planting response is restricted to positive values, such that if the value implied by equation (1) is negative, a value of zero is given for the area of plantings in that year.

where P_t is the price per pound of pistachios, Y_t is the yield per bearing acre of pistachios, and the product is thus average revenue per bearing acre of pistachios, all in the year *t*. We used a value of 2.0 for the elasticity of plantings with respect to revenue per acre.[9] This value implies a modest rate of supply response to a change in incentives. To represent the impact of the marketing order on the supply of pistachios we modified the expectations variable as follows

$$E_t\left(PV_t\right) = (1+g)\tfrac{1}{5}\sum_{n=0}^{4} R_{t-n} = (1+g)\tfrac{1}{5}\sum_{n=0}^{4} P_{t-n} \times Y_{t-n} \qquad (3)$$

where *g* is the proportional increase in the present value of revenue per acre under the marketing order relative to the baseline, for the scenario in question (defined by the values for the elasticities, underlying growth in yields and demand, and marketing order impacts on demand) over the 50 year projection, 2000-2050. This value is estimated for each scenario by simulating the stream of prices and yields with and without the marketing order, taking the annual average across the alternative yield streams, and then computing the present value of those annual benefits. That is

$$1+g = \frac{PV\left(R^M\right)}{PV\left(R^B\right)} = \frac{\sum_{n=1}^{50}(1+i)^{-n} P_{t+n}^M Y_{t+n}^M}{\sum_{n=1}^{50}(1+i)^{-n} P_{t+n}^B Y_{t+n}^B} \qquad (4)$$

where *PV(R)* denotes present value of revenue per bearing acre, superscripts *M* and *B* refer to the values under the marketing order and in the baseline, without the marketing order, and *i* is the real discount rate, set at 4 percent per annum. A process of iteration is

[9] In the very long run, pistachio acreage can continue to expand substantially, as it has in the past, and we could expect to see a very high supply response to a permanent and substantial price increase. (Alston et al. 1995 discuss this issue in relation to almonds, and the same arguments apply to pistachios.) Intermediate figures apply to the current investigation. However, we note that producers will only supply pistachios to the market at a price that is above the harvesting cost. We use harvesting costs per pound of $0.12, based on University of California Cost and Returns studies (University of California Cooperative Extension).

used to solve for the value of g that is consistent with the model solutions it engenders, which results when the model solution stabilizes.

Bearing acreage evolves according to

$$B_t = (1 - r_t)B_{t-1} + PL_{t-7} \tag{5}$$

where B_t is the bearing acreage in year t, which is equal to the value in the previous year less the amount removed in that year, which is defined by the proportional removal rate, r_t (0.01 for years up to 2015, and 0.02 thereafter) plus an increment equal to the number of trees planted in the year seven years previously.

Yields per bearing acre vary over time reflecting both the alternate bearing habit of pistachios and the influence of other random variables, as well as trending up to reflect both technological improvements and the maturation of young bearing trees. To capture these characteristics we used a trend model of the following form:

$$Y_t = (1 + y)^t Y_0 \left(1 + u_t\right) \tag{6}$$

where Y_t is the projected yield per bearing acreage in year t, which is equal to the value in the base year, scaled up by exponential growth at a rate y, and adjusted by an annual proportional shock, u_t[10].

Production is simply the product of yield per bearing acre and the number of bearing acres:

$$Q_t = Y_t \times B_t. \tag{7}$$

[10] The values for u_t were obtained by first computing the past values of year-to-year variations around trend yields. We extended that series to a length of 100 observations by replicating the sequence, and then drew a series of 50 by selecting a starting point at random within the 100 observations. This series represents one 50-year sequence of random shocks which, combined with equation (6), allows us to generate a single "future" of yields over 50 years. Alternative futures were generated by drawing alternative starting points. A total of 100 such futures were generated and used in the simulation models.

Annual demand consists of two distinct markets, the domestic and the export market that are treated differently by the marketing order, as well as demand for changes in stocks. We specified linear equations for quantities demanded on the domestic market (DD_t), on the export market (DE_t), and for storage (DS_t), t years in the future, as a function of the price of pistachios (P_t) in that year, as follows:

$$\begin{aligned} DD_t &= \left(d_0 - d_1 P_t\right)\left(1+d\right)^t \\ DE_t &= \left(e_0 - e_1 P_t\right)\left(1+e\right)^t \\ DS_t &= \left(s_0 - s_1 P_t\right)\left(1+s\right)^t \end{aligned} \qquad (7)$$

Values for the slope and intercept parameters for each of these equations were estimated using elasticities and initial values for prices and quantities in the base year, using five-year averages, 1997-2001. Values for the growth rate parameters (d, e, and s), were chosen to reflect underlying growth rates in demand. Initial values of these were chosen in view of the past trends in consumption, after allowance for the effects of trends in prices. Values for the demand elasticities were based on a combination of our own econometric estimations, other econometric estimates in the literature, and judgment based on knowledge of the industry and some introspection. When estimating models of demand for U.S. pistachios in aggregate, and for U.S. consumption, we obtained some reasonable results and plausible elasticities. In a range of specifications, the overall elasticity was estimated as about -2, and the domestic elasticity as about -1. These estimates are consistent with elasticities of demand for exports and storage of about -3, which are plausible.[11]

[11] We do not have in mind any specific formal model of storage behavior, except that the demand for stocks slopes down such that current stocks will be greater when the current price is lower – a view that is consistent with various models of storage behavior and its motivations. Our limited econometric analysis found support for this view. Storage response is important in our context, because increased storage may

The sum of the three elements of demand represents the total demand (i.e., $D_t = DD_t + DE_t + DS_t$) which can be solved for price to obtain the inverse demand equation, as follows:

$$P_t = \frac{d_0(1+d)^t + e_0(1+e)^t + s_0(1+s)^t - Q_t}{d_1(1+d)^t + e_1(1+e)^t + s_1(1+s)^t} \qquad (8)$$

Then, substituting for Q_t, we can solve for the market-clearing price, which we can substitute in turn into the equations for individual elements of demand, and for plantings, in a recursive process.

Two measures of producer benefits associated with the policy are computed as differences, for any given scenario, and for each year of the simulation. First, we compute the difference between the with- and without-marketing order simulations in gross revenue per bearing acre. An alternative measure of producer benefits is the change in profit or producer surplus. The explicit measurement of profit or producer surplus is difficult in a setting with dynamic supply response, and requires an explicit cost function, which we do not have. Therefore, we devise an approximate measure of producer surplus, which is

$$\Delta PS_t \approx R_t^0 \left[d \ln R_t - d \ln Q_t \right]. \qquad (10)$$

where superscript "0" in R_t denotes the gross revenue at time t without the marketing order case.

Annual domestic consumer benefits are computed as changes in Marshallian consumer surplus, the area behind the domestic demand curve, reflecting the effects of

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be an important mechanism for the industry to absorb a *temporary* demand shock. Our representation of storage response is necessarily simple, but a better option than treating storage as exogenous and not relevant to the analysis of the consequences of a demand shock.

both price changes and shifts in the demand. The annual national benefits are equal to the sum of producer and consumer benefits.

The annual producer, consumer, and national benefits are discounted back and expressed in present value terms. The producer benefit-cost ratio is computed as the ratio of the present value of producer net benefits divided by the present value of the producer incidence of the assessment to finance the policy. Another index of the economic impact of the policy is the national benefit-cost ratio, computed as the present value of national benefits divided by the present value of the costs of the program (the cost of both the assessment to finance the program and other costs of compliance with the program), which is represented in the model by the cost of the assessment.

Cost of Testing and other Compliance Issues

The quantitative economic analysis requires information on the costs of aflatoxin testing and compliance with other quality standards as regulated under the marketing order. Depending on the current level of testing and other characteristics, processing firms face different costs of complying with the proposed standards under the marketing order, in essence the cost for aflatoxin testing of pistachios destined for the domestic market and meeting quality standards. A telephone conference with the seven major processors in California provided data on the cost that various processors of the California pistachio industry would face under the proposed marketing order (Pistachio Processor Group).

In his testimony at the hearings on July 25, 2002, Daniel Sumner described in detail how to estimate these costs for three different types of processors, depending on their current testing practices and the size of their processing operation, based on labor requirements and wage rates for inspectors, lot sizes, and various other factors. The resulting estimate of the direct per unit cost of compliance was a weighted average (across the different types of processors) of $0.00525 per pound on the two-thirds of production to which the proposed marketing order rules apply. This figure seems to be a consensus estimate in the industry.[12] The weighted cost of compliance applied across the entire California pistachio production is $0.0035 per pound. These figures are based on an assumption that few undersized pistachios are currently sold in the standard market such that the implementation of the other features of the marketing order would not have significant implications for the total quantity available to the domestic market.[13]

Effects on the Probability of an Aflatoxin Event and its Consequences

Direct evidence does not exist on the probability of an aflatoxin event that would cause a major negative shock to demand when it occurred, nor on the likely severity of the shock. We assume that increased aflatoxin testing would reduce the probability of such an event, and may reduce the severity of the shock as well, but again we have no direct quantitative evidence on the relevant magnitudes. To calibrate the potential effects of a pistachio food scare we used information from other produce-related food scares in the United States, along with information from an event involving pistachios in Germany, and we conducted sensitivity analyses in which we varied the relevant parameters.

After the EU banned pistachio imports for three months in the last quarter of 1997 because of aflatoxins, German imports remained substantially reduced over the next three

[12] The Federal register (2003, p. 46017) reports "The average cost of compliance, as identified by several witnesses and reiterated in Dr. Sumner's analysis, is approximately one half cent per pound of domestic pistachio production, or $0.00525 per pound."

[13] In any event, under the marketing order, undersized pistachios could still be diverted to the export market and so the consequences of this element of the regulations for prices, quantities, and values would be negligible.

years, an estimated reduction in demand in the range of 40-50 percent. The pistachio market is relatively small and other nuts and snack foods are likely to be close substitutes for pistachios. This may be why the losses for pistachios in the EU market were larger than observed in some other food scares in the United States, but the differences also might reflect some differences between the United States and other countries – in terms of institutions and consumer behavior – which means the responses would be different.

Taking a conservative approach, we assumed that an aflatoxin event in the domestic market for U.S. pistachios in year *t* would cause a 30 percent reduction in demand in the year of the event (i.e., $\delta_t = 0.3$, where δ stands for the proportion by which demand decreases in year *t)*. The German evidence suggests that the negative demand effects from a single aflatoxin event would continue to affect demand for several years. The negative demand shock decays at a rate of 30 percent per year (i.e., $\delta_{t+n} = 0.7^n\delta_t$).

Aflatoxin events do not happen every year, but the market always faces some probability of a food scare. The benefit from additional testing is a reduction of the probability of an aflatoxin event or food scare. For the current base case of no mandatory testing, we use an annual probability of 4 percent of an outbreak that affects demand as specified above. We assumed that with mandatory testing the chance of an aflatoxin outbreak would fall to 2 percent and that the events, when they do occur, would have smaller effects on demand. We assumed an initial downward shock of 15 percent with a marketing order rather than the 30 percent that would apply otherwise.

Effects on Consumer and Buyer Confidence

The demand for pistachios might be higher because of the official USDA certification ensuring a good quality product. Many agricultural products take advantage of USDA grading and other services (USDA, AMS). Many consumers in the United States are well aware of USDA standards. Buyers for major food outlets are familiar with USDA standards. In general, USDA standard setting is thought to convey a positive benefit in a market as reflected by the use of this claim in product promotion, labels and display. We are not aware, however, of empirical evidence of the magnitude of the impact of certification. Here, we use a small increase in demand to reflect greater buyer confidence in pistachios due solely to the USDA's participation in the standards process.

In addition, but similarly, the demand for pistachios will be higher with mandatory minimum quality standards and better buyer perception of safety. These standards would reflect well on the product as a whole and shift out demand for all pistachios because buyers would have lower probabilities of acquiring low quality shipments. This demand effect also has two aspects. The first is the general notion that buyers are willing to pay more for higher quality nuts. Second, the minimum quality standard assures buyers that they have a smaller chance of a low-quality shipment. This effect relies on more information being available to buyers that all pistachios from the marketing order area meet minimum standards. One of the provisions under the proposed marketing order prohibits the sale of inferior pistachios. Although these represent a tiny fraction of total production, removing them from the market altogether will result in an increase in the general quality of pistachios, albeit a small increase. To reflect both of these elements, in the simulations we allow for a small increase in demand in every year, relative to the base case, in response to the introduction of the marketing order: an increase in U.S. consumers' willingness to pay for pistachios equal to 1 cent per pound (about 1 percent of recent prices).

6. Results of Benefit-Cost Analysis

To estimate the impact of the marketing order we computed and compared a pair of fifty-year simulations (i.e., one with and one without the marketing order) using the "baseline" values for the parameters, as shown in Table 1. For each year of the fifty-year simulation, the model determines a market-clearing price, bearing acres, acres planted, yield, production, domestic quantity demanded, export quantity demanded, ending stocks, revenue, and consumer surplus. To capture the effects of random yield variability and aflatoxin-related demand shocks, the 50 years of simulated equilibrium values were calculated for a set of 100 equally likely futures, which differ in terms of values for randomly generated yields and aflatoxin shocks. Hence, in a given scenario, each simulated variable of interest has a fifty-year time path, with a random distribution in each period, which is affected by the marketing order. It is important to keep this time path and the random nature of the variables in mind.[14]

Under the marketing order, as shown in Table 2, the annual probability of an aflatoxin event is reduced from 4 percent to 2 percent, and the demand impacts of such an event are assumed to be half as large (i.e., an initial drop of 15 percent in demand versus 30 percent, applied to both the domestic market and relevant export markets). In addition to this benefit the marketing order is assumed to increase the domestic consumers' willingness to pay for pistachios by 1 cent per lb. The cost of compliance with the marketing order, 0.525 cents per pound consumed domestically, is reflected as a reduction in the price to growers for domestic sales.

[14] Further details on the simulation model and alternative parameterizations may be found in the more comprehensive full report on the study (Gray et al. 2004).

The impacts of the marketing order are reported in the first column of numbers in Table 2. To summarize the effects of the marketing order over the 50-year simulation we report average effects over the 50 years for some variables and for others we report the net present value in 2003 of the effects over the 50 years. The policy would modestly increase the average price received by growers (by 0.5 cents per pound, or 0.6 percent), along with the average number of bearing acres (by 1,870 acres or 1.3 percent) and production (by 12.6 million pounds per year or 1.5 percent). These increases in production are associated generally with increases in domestic consumption (by 11.5 million pounds per year or 2.8 percent) and in exports (by 1.0 million pounds per year or 0.2 percent) and decreases in stocks (by 0.6 million pounds per year or 0.3 percent). These averages mask the fact that, as noted above, the effects on some of these variables change over time both because of trends (the production response to the policy increases with time whereas the domestic demand response begins immediately) and from year to year (through the interaction of policy-induced changes in bearing acreage and variable yields). This is true in particular for the effects of the policy on exports – the small average effects reflect negative impacts in some years, especially initially, and positive impacts in others, especially in the later years.

The dynamics of the impact of the marketing order on revenue per bearing acre, bearing acres, and domestic consumer surplus are particularly interesting. The marketing order increases grower price and revenue per acre by increasing consumer confidence and reducing the odds and the impact of an aflatoxin event. The impact on revenue is greatest in the first few years after the introduction of the marketing order because supply is unaffected for this period. The increase in revenue per acre eventually causes an increase in the time path of bearing acres. The increase in bearing acres results in increased production, driving down prices and revenue per acre, and dissipating the benefits for producers. Consumers gain initially from the improved food safety and these benefits are then augmented by the subsequent reductions in prices resulting from the increases in production.

The net benefits from the policy – reflecting the consequences of both the assessment and regulations, and the demand and supply responses to them – are expressed as present values (in 2003) of changes in economic surplus accruing to different groups. These net benefits include $68.9 million to domestic producers and $165.4 million to domestic consumers, yielding a total national net benefit of $234.2 million.[15] From a global perspective, the U.S. net benefits are slightly offset by net losses in foreigner surplus (the "consumer surplus" measured off the demand for U.S. exports) worth $25.0 million, leaving global net benefits with a present value in 2003 equal to $209.2 million.[16]

We also estimated the total cost of the policy (in terms of expenditure incurred by processors in compliance), which had a present value in 2003 of $36.7 million. The initial incidence of this cost is on processors, but this incidence is redistributed over time through supply and demand responses. To evaluate the final incidence, we ran a

[15] On 78,000 bearing acres in 2001, the producer benefit is worth $2,120 per acre, but the benefits would not be confined to these acres.

[16] The positive effect on export quantity seems to contradict the higher average price and the reduction in foreign "consumer" surplus associated with the policy. The effect on foreign "consumer" surplus is complicated. First, there are some benefits to foreigners from the policy because in the baseline, there is a spillover of an aflatoxin event from U.S. demand to foreign demand and the policy-induced reduction in probability and severity of an aflatoxin event applies to export markets as well as domestically. These benefits are offset at least somewhat by the larger domestic demand responses, driving up prices, especially in the early years; in the later years those effects in turn are offset at least somewhat by the consequences of U.S. supply response to the policy. The benefits to foreigners are greater in the earlier years, and given discounting, the net present value is negative even though the average effect on quantity of exports, undiscounted, is slightly positive.

simulation with just the assessment (modeled as a reduction in domestic buyers' willingness to pay of 0.525 cents per pound) and, in present value terms, we found that 15 percent of the cost was borne by growers, 85 percent by domestic and foreign consumers combined, and 95 percent by domestic consumers (foreign consumers are net beneficiaries of a tax on domestic consumers). Hence the incidence of the global cost of $36.7 million was $39.7 million on the United States, including $5.5 million on U.S. producers. By dividing each measure of net benefits by the corresponding measure of the incidence of the costs we obtained a ratio of net benefits to costs (i.e., (B-C)/C) to which we added one to compute conventional benefit-cost ratios (B/C) for domestic producers (13.5), the United States (6.9) and the world (6.7).

To examine the general sensitivity of results to modeling assumptions, we devised a "high-impact" scenario and a "low-impact" scenario, and the summary results for the simulations under these scenarios are reported in second and third columns of numbers in Table 3. For the high-impact scenario we altered most of the parameters of the model by 10 percent in the direction that would increase the impact of the policy; for the low-impact scenario we altered the parameters by 10 percent in the opposite direction. These scenarios reveal how the results would be affected by a modest but consistent upward or downward bias in parameter values. As shown at the bottom of the table the combined effect of the parameter changes creates a larger than 10 percent variation in the estimated impacts of the marketing order. Compared with a benefit-cost ratio for producers of 13.5 in the base scenario, the ratio is 20.8 (50 percent higher) in the high-impact scenario and 9.6 (30 percent lower) in the low-impact scenario. Similarly for the United States as a whole, compared with a benefit-cost ratio of 6.9 in the base scenario, the ratio is 10.2 (50 percent higher) in the high-impact scenario and 3.8 (45 percent lower) in the low-impact scenario. Nevertheless, the benefit-cost ratios are all well greater than zero, even in the low-impact scenario, indicating that the policy entails substantial net benefits for both producers and the nation as a whole.

7. Conclusion

An aflatoxin event could impose serious costs on the California pistachio industry. The proposed marketing order is intended to reduce the odds of an event, to mitigate the consequences if an event should occur, and to provide some quality assurance to buyers, to offset the negative consequences of concerns over the potential for a food scare affecting pistachios. In this study we have modeled the market for California pistachios to provide an ex ante assessment of the benefits and costs and other consequences of the proposed marketing order looking forward for 50 years from its likely introduction in 2004. Our approach uses a stochastic dynamic simulation of the industry under scenarios with and without the proposed marketing order in place, to compare the stream of simulated outcomes and the consequences for measures of economic welfare of producers in the industry, consumers, the nation as a whole, and globally.

To assess the implications of the marketing order required incorporating into the simulation a number of parameters representing the odds of an aflatoxin event, its consequences for demand, and the extent to which a marketing order would reduce those magnitudes. Many of these parameters are hard to estimate because relevant historical data are not available on pistachios. As well as simulating the consequences implied by "best-guess" values for key parameters, we undertook sensitivity analysis. Across the full range of parameters used in the analysis, the benefit-cost analysis was always favorable to the policy: the measured benefits to producers, the nation, or the world always well exceeded the corresponding measure of costs, typically by many times. The benefit-cost ratios were generally greater than 5:1 and often greater than 10:1, which means there is substantial leeway to accommodate potential errors in assumptions and yet have favorable findings. In present value terms, the benefits to producers were estimated at $68.9 million. Two-thirds of the benefits, $165.4 million would accrue to domestic consumers. These are significant values, and are large relative to the cost of compliance with the program, which is a very small amount – about half of one percent of the current value of domestic sales.

Table 1: *Key Parameters for the Simulation Model*

Parameter	Baseline Value
Underlying Market Conditions	
Elasticity of domestic demand	-1.00
Elasticity of export demand	-3.30
Elasticity of demand for stocks	-2.00
Long-run annual growth rate of demand (percent)	3.60
Elasticity of new plantings response to profitability	1.00
Impact Parameters without a Marketing Order	
Probability of an aflatoxin event (percent per year)	4.00
Initial impacts of an event (percentage reduction in domestic demand)	30.00
Foreign demand shock/ domestic demand shock (percent)	21.50
Impact Parameters with a Marketing Order	
Probability of an aflatoxin event (percent per year)	2.00
Initial impacts of an event (percentage reduction in domestic demand)	15.00
Initial impacts of an event (percentage reduction in foreign demand)	21.50
Compliance costs (cents per pound)	0.525
Domestic demand enhancement from certification (cents per pound)	1.00

Table 2: *Simulation Results: Benefit-Cost Analysis of the Pistachio Marketing Order*

Consequences of the Marketing Order	Baseline	High Impact	Low Impact
Average of Annual Values, 2000-2050, Induced Changes in			
Price of California pistachios (real cents per pound)	0.501	0.726	0.371
Bearing area of California pistachios (acres)	1,866	2,716	1,279
Production of California pistachios (million pounds)	12.55	18.31	8.63
Domestic consumption of California pistachios (million pounds)	11.54	16.91	8.15
Exports of California pistachios (million pounds)	1.01	1.40	0.51
Stocks of California pistachios (million pounds)	-0.62	-1.05	-0.47
Present Values in Year 2000, Net Benefits, $million			
Changes in U.S. consumer surplus (CS)	165.4	246.7	109.8
Changes in California producer surplus (PS)	68.9	103.7	49.6
National benefits (NS = CS+PS)	234.3	350.4	159.4
Net changes in foreign surplus (FS)	-25.0	-36.5	-19.2
Global net benefits (GS = NS+FS)	209.3	313.9	140.2
Present Values in Year 2003, Costs of Marketing Order, $million			
Cost of compliance (CC)	36.7	34.9	38.4
Benefit-Cost Ratios			
Global B/C ratio (1+ [GS/CC])	6.7	10.0	4.7
National B/C ratio (1 + [NS/1.1CC])	6.9	10.2	4.8
Grower B/C ratio (1+ PS/0.15CC])	13.5	20.8	9.6

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