ESTIMATING THE IMPACTS OF DIFFERING PRICE-RISK MANAGEMENT STRATEGIES ON THE NET INCOME OF SALINAS VALLEY LETTUCE PRODUCERS: A STOCHASTIC SIMULATION APPROACH

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While government safety-net programs are used to mitigate the price risk for commodity producers, limited programs exist for specialty crop producers. Specialty crop producers utilize forward contracts to reduce downside price risk. In order to estimate the method of price-risk management, if any, that is preferable to selling at market determined prices, a stochastic simulation model was constructed. The completed simulation model was used to estimate probability distributions for Salinas Valley net income under different pricing scenarios. Probabilities of reaching various net income thresholds were compared. Results indicate that Salinas Valley lettuce producers should maximize profitability by using forward contracts.

Farming has historically been a risky venture, with the amount of risk being a function of many factors. Traditionally, price and yield risk have been recognized as the primary challenges causing financial uncertainty for agricultural producers. Many producers recognize that risk has some benefit, and that while risk is associated with the possibility of less than desirable outcomes, it is also associated with the possibility of greater reward. Economists distinguish between risk and uncertainty; risk is associated with a known probability distribution, whereas there is no known or expected probability density function when dealing with uncertainty (Roberts, et al). Accurate estimates of the probabilities of particular outcomes for price and yield help to change uncertainty to measurable risk.

Methods of reducing price risk do exist, and take one of two general forms: Policy mechanisms and market mechanisms. Policy mechanisms are defined as risk controls that result from official government policy. Market mechanisms are defined as those

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measures taken at the sole discretion of market participants, as a conscious means of managing risk (Roberts, et al). Researchers are continually examining the effects of these different mechanisms in reducing income variability, as well as their effects on the long-run net income of agricultural producers.

Government policy has been implemented on an ongoing basis, in order to help agricultural producers reduce their risks. Historically, government programs have taken the form of price supports and supply control programs. In recent years, government policy has been expanded to include counter-cyclical payments and increased subsidies on yield and revenue insurance. Most price support programs have traditionally been administered through the Commodity Credit Corporation. Direct payments from the federal government to farmers in the U.S. exceeded $20 billion per year 1999-2001. Nearly all payments went to corn, soybean, wheat, rice, and cotton producers. Federal crop insurance programs include provisions for specialty crops[1], however, revenue limits have made participation by most specialty crop producers negligible (Roberts, et al).

The lack of comprehensive safety-net programs for specialty crops is in part due to the fact that the number of commodity producers far exceeds the number of specialty crop producers in the United States. Therefore, commodity producers tend to have more political power than specialty crop producers (Hamilton). Commodities are produced in the vast majority of U.S. states, while a small number of states produce the majority of many specialty crops. For example, as of 2001, California and Arizona produced approximately 96% of U.S. lettuce (Glaser, et al). Corn, in contrast, was grown commercially in over one half of all U.S. states. Lastly, some specialty crop growers embrace the risk involved in their operations, and believe that a price support would actually make them less profitable, because supply would tend to increase with a decrease in risk (Bunn).

California specialty crop producers in general and Salinas Valley lettuce producers specifically, have relied on market mechanisms such as forward contracting, rather than government programs, in order to mitigate price risk. Nearly 100% of Salinas Valley lettuce producers use some form of contract arrangement (grower/shipper panel). Growers will often contract with buyers on an annual or seasonal basis, specifying the price, quality and quantity of the product that will change hands at some point in the future. The proliferation of forward contracts is often associated with the growing market concentration at all levels of the value chain (Carriquiry and Babcock).

The growth of single source buyers from large chain stores such as Wal-Mart has created an environment in which lettuce producers have an increasingly smaller number of potential buyers for their product. Large buyers have the capacity to commit to purchasing the entire output of individual firms. Therefore, producers view this strategy as a way of always having a “home” for their production, and a way to remove price risk from their market. However, while forward contracting does help to eliminate the extreme downside risk in prices, it adds a new form of price risk, because these contracts can exclude producers from receiving extremely high prices in times of price spikes (Carriquiry and Babcock).

An issue for Salinas Valley lettuce growers is: What method of price risk management, if any, is preferable to selling at market determined prices, given the objective of maximizing the long-run profitability of the Salinas Valley head lettuce industry? The challenge in answering this question is in accurately identifying and

quantifying the costs and benefits from different risk control mechanisms that accrue to lettuce growers.

In this paper, we estimate the future benefits and costs of differing price-risk management mechanisms on the net income of Salinas Valley lettuce producers. Salinas Valley lettuce was chosen as it is representative of a broad group of perishable specialty crops for which no government price support exists, and for which forward contracting has become commonplace. The Salinas Valley lettuce industry plays a large economic role in both California and U.S. agriculture. Moreover, the industry is interesting because earlier studies on the costs and benefits of forward contracting have been done on non-perishable commodity crops, in which the assumptions of perfect competition are more closely intact. We find that given the assumptions made, forward contracting optimally mitigates price risk for Salinas Valley lettuce producers by maximizing the long run profitability of that industry.

Background

The California agricultural sector plays a vital role in the U.S. agriculture industry. California ranks first among states in total market value of agricultural products. In 2002, total California agricultural output was valued at nearly $26 billion. California specialty crops represent a large portion of the total agricultural output of the state, and in 2002 were valued at approximately $23 billion. California was ranked as the number one state producer of fruits, vegetables, nuts, nursery, and dairy products (2002 USDA Census of Agriculture).

The sheer size of the Monterey County lettuce industry indicates the significance of this project in terms of the industry's financial importance to both California and U.S. agriculture. Monterey County, California was ranked as the number one U.S. county in total value of crop production (over $2 billion in 2002), and number one in vegetable production and lettuce production specifically. Lettuce accounted for the highest total value crop produced in the county, at a value of over $738 million, which dwarfed the number two ranked broccoli at $266 million (2002 USDA Census of Agriculture).

Forward contracting has become very commonplace in the specialty crop industry. Growers will often contract with buyers on an annual or seasonal basis, specifying the price, quality and quantity of the product that will change hands at some point in the future (Glaser: May 2001). For example, nearly 100% of Salinas Valley lettuce producers use some form of contract arrangement (Bunn, et al). Carriquiry summarizes the reasons for this proliferation in forward contracting; farmers enter into contracts to reduce price risk and to increase their financial leverage. Buyers enter into contracts to reduce price risk and to maintain a predictable, high quality source of supply. Buyers also use contracting as a way to induce risk-averse farmers to produce a higher quality, more value-added product. Roberts, et al suggest that the increased use of contracts is associated with the growing market concentration at all levels of the value chain. The growth of single source buyers indicates an increase in monopsony power, and can cause a distinct marketing challenge for those producers who have not built relationships with the few large buyers.

The effects of an increasingly monopsonistic market in the specialty crop industry are compounded by the increasing costs of production. As specialty crop yields per acre

increase, they help to keep marginal costs lower, even in the face of increasing total costs. However, as certain costs outpace yield increases, rising land rents for example, it becomes increasingly important to producers to attempt to stabilize output prices at a high enough level in order to cover costs (Bunn). By forward contracting at a level that is above expected costs, producers can help to eliminate the risk of losing money. However, yield risks still exist, and lower than expected yields can result in making a seemingly profitable contract actually unprofitable.

Carriquiry and Babcock offer a framework for describing how economic factors influence the contracting behavior of farmers and processors, and found that participation in both spot and contract markets arises as a Nash equilibrium for a range of contract prices. Their paper also analyzes the effect of contract price on the relative profitability of farmers and processors; indicating that processors and farmers have conflicting preferences with regard to contract price. Carriquiry and Babcock empirically show that the price chosen by one party, if allowed to do so freely, would be the least desirable to the other party. Their paper also mentions that the move toward production under contracts has some concerned about the viability of remaining spot markets, which can be associated with lower quality output.

Menkhaus, et al, indicate that it is still undetermined if producers are better off utilizing forward contracts as opposed to spot markets. They do suggest that sellers may be better off using spot markets, in the sense that total earnings are higher, however sellers face risks in using forward contracts, because per unit costs are unknown at the time of the agreement, which is primarily due to fluctuations in yield. The unknown costs and benefits of forward contracting make the present research both timely and beneficial to specialty crop producers.

Review of Lettuce Models

In order to establish a starting point for both the theoretical and empirical modeling in this paper, three previous lettuce models were reviewed. Strengths, limitations, and applicability to this research question were identified. An overview of each model follows, beginning with the earliest, and ending with the most recent.

The Baires and Clevenger (BC) econometric lettuce model, published in 1977, was used as a primary source of theoretical relationships for the model in this paper. In the BC model, acreage planted was a function of acreage planted in the previous period and price in the previous period, and yield was a function of price. They also pointed out that even in the 1970's acreage planted decisions were based on the number of acres that could be forward contracted. Output price at time of harvest was found to determine the proportion of lettuce harvested and shipped, and the proportion of lettuce plowed under.

In addition, BC recognized that a suitable lettuce model must take into consideration weekly fluctuations in price and yield. They also recognized that the lettuce industry is characterized by long periods of low prices followed by short periods of relatively high prices. One limitation of their model is that it did not use a calculated index to estimate weekly variables. Instead it simply divided the seasonal results by the number of weeks in the season.

Hammig and Mittelhammer (HM) reported that the lettuce market they modeled exemplified a situation in which the assumptions of perfect competition do not exist, and

that a relatively small number of producers control the vast majority of lettuce production (1980). Their model featured no long-term storage of lettuce, that imports are negligible, but significant exporting does take place. They found that expected price was a significant determinant of acreage planted, that expected price was based on prices received in earlier periods, and that acreage with respect to expected price and variable production costs is inelastic. They also recognized that on the average, four to five percent of planted lettuce is not harvested due to crop damage and due to the economic decision not to harvest. If the market price at time of harvest will not cover the harvest costs, then the lettuce is plowed under. Their model was used to assess the impacts of wage increases paid to farm labor. Like the BC model, the HM model reported point estimates only.

The U.S. Lettuce Supply and Utilization model developed by the National Food and Agricultural Policy Project (NFAPP) at Arizona State University was used as the starting point for modeling the lettuce subsector in this project. The NFAPP model estimates U.S. supply and utilization through 2012 by using twelve regression equations, which produce point estimates for Arizona harvested acreage, Arizona yield per acre, California harvested acreage, California yield per acre, other U.S. harvested acreage, other U.S. yield, import quantity, export quantity, domestic consumption, retail-grower price margin, Arizona grower price, and California grower price. The present research project augments the statistical methods used by NFAPP, by combining stochastic simulation with deterministic results in order to directly estimate probability distributions.

Contributions of this Research

Currently, there is a lack of up-to-date price-risk analyses, which incorporate the stochastic risks faced by Salinas Valley lettuce producers. Forward contract pricing is widely used by Salinas Valley lettuce producers, but the future costs and benefits of that strategy have not been empirically estimated. Other specialty crop sub-sectors share similar attributes with the Salinas Valley lettuce industry, and therefore face similar price-risk management challenges. The contribution of the analysis presented is that it offers a current, robust, empirical, decision-making framework for Salinas Valley lettuce producers. Furthermore, the information offers a framework, which may be applied to other specialty crop industries.

This study supplements, with respect to providing relevant and accurate information about the costs and benefits of forward contracting, other forward contracting studies in one critical way. Studies to date have evaluated the costs and benefits of forward contracting pertaining to storable commodities. The ability to store a harvested crop allows for the harvesting of that crop even when the current market price is below the cost of harvest. Hence, production that is not under contract at the time of harvest might still be contracted, or may be sold on the cash market in the future. Therefore, the ability to store a crop offers producers greater flexibility in marketing strategies, which affects the potential costs and benefits of forward contracting.

Lettuce producers accrue costs and benefits of forward contracting differently, because the perishable nature of their crop reduces flexibility in the timing of their contracting decisions. When lettuce is ready to be harvested it must be sold and shipped immediately. If the lettuce is under contract, then it is harvested and shipped regardless

of expected negative returns. If lettuce is not contracted then it is either harvested and sold at current cash market prices, or it is plowed under. Due to the perishability of lettuce, lettuce producers must contract production well in advance of harvest to ensure that they can quickly ship their product once it leaves the field. A truncation of average market price was proposed, which accounts for the potential economic decision not to harvest. In addition, contract prices were based on expected costs, to account for the timing of contract decisions in the lettuce industry. The use of this method accounts for the possibility of negative returns under a forward contracting scenario.

This study supersedes, with respect to accounting for the stochastic nature of the lettuce industry, other head lettuce models, due to its use of stochastic simulation. Lettuce models to date have reported point estimates of endogenous variables, based on deterministic equations. Standard errors are also reported, which allows for the estimation of confidence intervals. However, the use of mean and variance estimates to calculate confidence intervals lacks precision, particularly when distributions are not normal. In addition, lettuce producers might find the procedure cumbersome and ultimately unusable in making risky management choices.

The model proposed in this research directly estimates the entire probability distributions of endogenous variables by utilizing stochastic simulation. Hence, probabilities of risky outcomes are directly generated and reported. These results account for the true stochastic nature of the Salinas Valley lettuce industry, and therefore offer lettuce producers more realistic and useable information than past lettuce models.

Model Construction

Grower Panel

In order to correctly specify the Salinas Valley model, certain cultural, management and marketing practices were also identified. This information was obtained from a focus group of Salinas Valley lettuce producers and shippers. The information was used to refine the Salinas Valley model, which allowed for the construction of a more practical and useful lettuce model.

The panel shared the following information. Head lettuce is typically planted in the Salinas Valley between January and July, for harvest between April and October. The current average yield per acre in the Salinas Valley is approximately 850 fifty pound boxes. Lettuce producers plant so that they can harvest approximately the same amount of lettuce each week of the harvest period. Acres planted is a decision made prior to the beginning of the season, and is primarily driven by past acreage planted. If a farmer is a lettuce producer, then they will grow lettuce each year, with minimum fluctuation in the amount of acres planted. Once planting decisions are made, they are not adjusted intra-season based on price. Commitments made to buyers reduce much of the flexibility with respect to harvested acres. Price received during the last season is also a determinant of planted acres.

Forward contracts are typically entered into a year in advance, and cover the entire upcoming growing season. Contracts are based on an “open book” basis, with large buyers contracting at approximately 1-3% over the average cost of production. Average production costs in the Salinas Valley are approximately $8500 per acre for flat pack,

naked head lettuce[2]. All subsequent lettuce prices are based on the price of flat pack, naked lettuce. However, only 2-5% of Salinas Valley lettuce is packed naked.

The grower/shipper panel believes that most lettuce growers would not survive without forward contracting, and that government money would be more helpful if spent on marketing and production research, and to reduce tariffs, than being used for a safety net program. They also believe that any type of government safety net to reduce risk would actually make the producers worse off.

Salinas Valley

The theoretical model begins with annual Salinas Valley lettuce producer net income per acre as a function of the weekly price and yield for Salinas Valley lettuce less the total cost of producing and getting the lettuce to market. Weekly Salinas Valley yield is a function of technology, which changes over time, and the price of lettuce during a particular week. Due to the perishable nature of lettuce, if the price of lettuce is below the harvest cost per unit, then lettuce will not be harvested and will be plowed under. Weekly Salinas Valley price is determined by the supply and demand of lettuce during a particular week. Hence, annual Salinas Valley lettuce producer net income per acre can be modeled as

$$(1) \qquad NI_t = \left[\sum_{i=1}^{n} R(x_i) \right] - C(x_t)$$

and

$$(2) \qquad R(x_i) = f(T_i, Q_{si}, Q_{di})$$

where NI_t is annual net income per acre in year t; $R(x_i)$ is revenue per acre in week i; $C(x_t)$ is annual cost per acre in year t; T_i is week i; Q_{si} is quantity supplied in week i; and Q_{di} is quantity demanded in week i.

Since annual costs are a function of weekly output, variable input costs per unit, and fixed costs, while weekly output is a function of time and price, and price is a function of supply and demand, then annual cost per acre can be modeled as

$$(3) \qquad C(x_t) = f(T_i, Q_{si}, Q_{di}, VC_{xi}, FC_t)$$

where VC_{xi} is variable input costs per unit in week i, and FC_t is annual fixed costs per acre in year t.

While it may seem academic to outline the functional relationship between price, determined by supply and demand, and supply, these relationships have specific impacts of note when modeling a perishable crop such as lettuce. Producer theory suggests that supply is a function of expected price, which influences acres planted, and yield per acre. Furthermore, supply per acre is equal to yield per acre. While this convention may hold for non-perishable crops, Baires and Clevenger recognized that in perishable crops, potential yield exceeds the actual amount harvested. Hence, lettuce supply per acre is not equal to yield per acre. Since lettuce cannot be stored for any meaningful length of time, the crop will be plowed under if the weekly price cannot cover the harvest costs. Therefore, expected price influences potential supply, but spot price determines actual supply.

It follows that harvest costs are directly influenced by spot price, because the cost of harvest will not be incurred if the spot price falls below the harvest cost per unit. Hence, a simplifying assumption is made in this paper. It is assumed that the average annual price per unit of output cannot fall below the harvest cost per unit. If average price were to fall below the average cost of harvest, it would not be economically rational to supply lettuce.

In order to further simplify the Salinas Valley model, an assumption is made that average annual Salinas Valley prices and yields conform to a historical relationship with average California prices and yields. This assumption is based on the fact that over 90% of California lettuce is produced in the Salinas Valley. The true causal relationships could be modeled as

(4) $P_t^{CA} = f(P_t^S)$

and

(5) $YLD_t^{CA} = f(YLD_t^S)$

where P_t^{CA} is the average California price per unit in year t; P_t^S is the average Salinas Valley price per unit in year t; YLD_t^{CA} is the average California yield per acre in year t; and YLD_t^S is the average Salinas Valley yield per acre in year t.

However, the actual causal relationships between California and the Salinas Valley are not of primary concern. Accurate estimates of Salinas Valley yield and price are critical. Therefore, the simplifying assumption is that once annual California price and yield are estimated, those estimates can be adjusted to arrive at annual Salinas Valley estimates, based on historical relationships in which causality is not inferred. This method can result in underestimating the variability in Salinas Valley price and yield. To account for greater variability, annual Salinas Valley estimates were then reduced to weekly estimates using weekly indices, for use in equation (1).

California

Annual California yield is assumed to be a function of the expected price to be received by growers, and technology, which changes over time. Therefore, California yield per acre is modeled as

(6) $YLD_t^{CA} = f(EP_t, \text{Trend})$

where YLD_t^{CA} is the average California yield per acre in year t; EP_t is the price expected by growers in year t; and Trend is a yearly counter.

Average annual California price in year t (P_t^{CA}) is assumed to have a historical relationship to average U.S. price in year t (P_t^{US}). While the true causal relationship is that P_t^{CA} affects P_t^{US}, the simplifying assumption is made that P_t^{CA} can be estimated as a mathematical relationship to P_t^{US}, without inferring causality.

United States

Supply and demand in the Salinas Valley have historical relationships with average California yield and average California price, which have historical relationships with U.S. yield and with total U.S. supply and demand. Hence, a model of supply and demand for Salinas Valley lettuce begins with an aggregate U.S. model:

(7) $Q_{st} = Q_{mt} + (YLD_t^{US} * HA_t)$

and

(8) $Q_{dt} = DD_t + XD_t$

where Q_{st} is total U.S. supply in year t; Q_{mt} is import quantity in year t; YLD_t^{US} is U.S. yield per acre in year t; HA_t is total U.S. harvested acreage in year t; Q_{dt} is total U.S. quantity demanded in year t; DD_t is domestic demand in year t; and XD_t is export demand in year t.

The theoretical model also assumes that U.S. harvested acreage and U.S. yield per acre are functions of the price expected to be received by growers. The expected price is considered to be the "naïve price expectation" (P^{US}_{t-1}) under spot market conditions, but can change when forward contracting and/or a government target price are implemented, such that:

(9) $EP_t = P^{US}_{t-1}$, under spot market pricing,
$= P_c$, under forward contract pricing, and
$= \max(P^{US}_{t-1}, P_g)$, under a government target price scenario

where P^{US}_{t-1} is the previous year's price; P_c is the forward contract price; and P_g is a hypothetical government target price.

Empirical Model Design

The empirical design was constructed beginning with the U.S. level model. After examining past lettuce models, six regression equations were estimated individually using OLS. U.S. level parameters affecting harvested acreage, yield, import quantity, domestic demand, and export demand were estimated. The sixth equation specified was California Yield. Parameters were estimated using annual data for years 1971 through 2002. The parameters were later used to estimate the values of the six variables for years 2003 through 2012.

In order to capture the associated risk in the deterministic models, the six regression equations were modified to be stochastic. The stochastic components are represented by the amount of historical error (residuals) in each equation. Stochastic shocks were simulated and combined with deterministic regression equations. The recursive, POLYSYS modeling method outlined by Ray and Richardson was used to simulate U.S. supply, demand, and price for years 2003 through 2012. The estimated export and domestic demand equations were combined and reduced, so that equilibrium price in year t could be solved directly from quantity supplied.

Statistical tests on the residuals from the regression equations revealed that not all distributions were normal, and that correlation existed between the equations' residuals. Hence, a multivariate empirical distribution of residuals was simulated. A matrix of correlated empirical deviations for the six variables was simulated for each of the ten forecast years. The simulated data matrix for each year was compared to the historical data matrix. Due to the multivariate nature of the data, Hotelling's T-Squared tests were conducted to test the null hypothesis that the mean vectors are equal, at the 95% confidence level. Next, Box's M Tests were conducted to test for homogeneity of covariance matrices at the 95% confidence level. The correlation matrices for the simulated values were then compared to the historical correlation matrix, in order to test whether or not the proper correlation between variables was maintained. A Student's t was used to test each of the coefficients.

California price was estimated directly from stochastic U.S. price using an adjustment factor; causality is not inferred. Annual Salinas Valley price and yield were estimated directly from California price and yield using adjustment factors; causality is not inferred. To account for any underestimation in variability due to the process described above, weekly Salinas Valley price and yield estimates were constructed. Seven years of weekly Salinas Valley price and yield data was used to estimate weekly indices. These indices were then used to adjust the *annual* Salinas Valley price and yield estimates to get *weekly* price and yield estimates.

Stochastic, weekly Salinas Valley price and yield estimates were combined to estimate annual Salinas Valley revenue per acre. University of California cost study data was adjusted using the estimated Fruit and Vegetable Producer Price Index, to estimate Salinas Valley cost per acre. Per acre revenue and cost estimates were used to estimate Salinas Valley net income per acre through 2012.

Results

The completed simulation model was used to estimate probability distributions for Salinas Valley net income under three pricing scenarios; free market price determination, forward contracting, and a hypothetical government safety net program. The price expected by growers depended on the scenario simulated, and therefore impacted supply. Under the free market scenario it was assumed that 100% of production was sold in the cash market. Under the forward contracting scenario it was assumed that 100% of production was sold at the contract price. Therefore, no scenario assumed partial forward contracting.

The three simulated distributions for each year were then used to calculate the probabilities of meeting specified net income per acre thresholds under each scenario. The three thresholds were defined as; less than or equal to zero, greater than zero, but equal to or less than $500, and greater than $500.

Six endogenous variables were estimated using the ordinary least squares approach. Historical data (1971-2002) was used to estimate the parameters of those six equations. The results of the parameter estimation are presented in Table 1. The size and signs of the coefficients matched theoretical expectations. Based on T-ratios, F-statistics, and the adjusted R^2 for each equation, the calculated equations represent a reasonable set of parameters for estimating the values of the six given variables. Based on the variance

Table 1. Regression Equations[3]

	R^2 Adj.				
U.S. Harvested Acreage	80.8	Coefficient	Std. Error	t-stat	p-value
Constant		34703.44	27760	1.250	0.222
EP_t		3011.02	669.6	4.497	0.000
HA_{t-1}		.793	.112	7.063	0.000
Trend		-1495.16	297.5	-5.025	0.000
U.S. Yield	92.5	Coefficient	Std. Error	t-stat	p-value
Constant		236.08	7.107	33.220	0.000
EP_t		-4.05	1.093	-3.705	0.001
Trend		6.04	.483	12.494	0.000
Import Quantity	67.1	Coefficient	Std. Error	t-stat	p-value
Constant		148922.22	143640	1.037	0.309
P_r		-8898.56	6229	-1.429	0.164
P_r^2		180.63	62.131	2.907	0.007
Domestic Demand	63.5	Coefficient	Std. Error	t-stat	p-value
Constant		51857266.81	2446297	21.198	0.000
P_t		-500877.65	358493	-1.397	0.173
Trend		782198.60	163997	4.770	0.000
Export Demand	57.6	Coefficient	Std. Error	t-stat	p-value
Constant		1059731.02	500791	2.116	0.043
Trend		-140280.98	26847	-5.225	0.000
Ln Trend		2157462.82	342853	6.293	0.000
California Yield	83.0	Coefficient	Std. Error	t-stat	p-value
Constant		258.27	10.715	24.103	0.000
EP_t		-4.84	1.648	-2.935	0.007
Trend		6.10	.728	8.375	0.000

inflation factors, there appeared to be no significant influence from multicollinearity. Moreover, Durbin-Watson statistics indicate that first-order serial correlation was either indeterminate or was not evident.

A matrix of correlated empirical deviations for the six variables was simulated for each of the ten forecast years. The simulated data matrix for each year was compared to the historical data matrix. Due to the multivariate nature of the data, Hotelling's T-Squared tests were conducted to test the null hypothesis that the mean vectors are equal, at the 95% confidence level. The P-value of the test for each year was near 1.00, and

therefore the null hypothesis was not rejected. The ten simulated mean vectors were found to be homogenous to the historical mean vector. Next, Box's M Tests were conducted to test for homogeneity of covariance matrices at the 95% confidence level. The P-value for each of the ten tests was near 1.00, therefore the null hypothesis was not rejected. The ten covariance matrices were found to be homogeneous to the historical covariance matrix. Next, the correlation matrices for the simulated values were compared to the historical correlation matrix, in order to test whether or not the proper correlation between variables was maintained. A Student's T was used to test each of the coefficients, and the correlation matrices were found to be statistically equivalent.

The use of empirical distributions in this model has two distinct advantages over using normal distributions. First, normality tests and visual appraisal of probability density functions suggests that the simulated empirical distributions would better fit the historical distributions. Secondly, if normal distributions were used, then the coefficient of variation for any variable exhibiting trend would not be stable over time. Since the units of the empirical distribution are in percent deviation, the coefficient of variation is stable regardless of trend. The normal distribution could be adjusted to be COV stable, but that would require further steps in the modeling process.

Historical average annual California price was compared to historical U.S. price. It was found that on average California price tends to be approximately 99% of the U.S. price in any given year. Therefore an adjustment factor of .99 was used to estimate California price from U.S. price.

A Pearson Correlation coefficient was estimated for the annual Salinas Valley price versus the annual California price for years 1996 through 2002. The correlation coefficient for Salinas Valley price was calculated to be .91, the correlation was found to be significant at the 95% confidence level. The stochastic annual California price estimates were multiplied by .91 to produce the stochastic annual Salinas Valley price estimates for 2003 through 2012.

Annual average yield per acre data from the Monterey County Agriculture Commissioner's Office was compared to the annual average yield data for California. It was found that on average, Salinas Valley yield tends to be approximately 16% higher than average California yield. Therefore, for model simulation the stochastic California yield estimates were multiplied by 1.16 to produce stochastic Salinas Valley yield estimates for 2003-2012.

The estimated Fruit and Vegetable Producer Price Index Base 1982 (FVPPI82) was used to adjust University of California cost data to estimate costs per acre for years 2003-2012. The estimated FVPPI82 values for 2003-2012 were collected from NFAPP. Total cost estimates per acre are shown in Table 2. Costs include all land preparation, cultural, overhead, harvesting, packing, and cooling costs.

The empirical results of the three simulated scenarios are presented in Table 3. The most profitable outcomes for each year are shown in green and the least profitable outcomes are shown in red. While the results can be viewed in different ways depending on the risk averseness of each individual, some general observations can be made. However, when interpreting the results, the following caveats should be kept in mind.

Table 2. Estimated Cost per Acre 2003-2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Estimated Cost ($/acre)	8055	8258	8490	8725	8939	9155	9375	9599	9826	10055

Caveats

This study assumes that the probability distributions of the six variables estimated using ordinary least squares regression conform to their historical norms through year 2012. Over 30 years of data was used to create the historical distributions, which at this time is the best indicator of future distributions. It is also assumed that the relationships between California and Salinas Valley data remain stable. The yield relationship between California and Salinas Valley was established using relatively few years of data.

It is assumed that the exogenous data collected is accurate. The weekly Salinas Valley data from Grower's Express is reported to be from the Federal State Market News, which is regarded to be one of the most accurate accounts of market data. The historical data collected from NFAPP was spot-checked against reported USDA data, and was found to match, therefore it is assumed to be from credible sources.

It is assumed that the forward contract level of 3% above expected costs is an accurate representation of a typical U.S. lettuce contract. The growers and shippers interviewed represent a cross section of the lettuce industry, and deal with lettuce production in both California and Arizona, where 96% of U.S. lettuce is grown. Therefore, their accounts of contract specifications should be fairly representative.

It is further assumed that a government target price set at 85% of the cost of production is a reasonable, hypothetical support scenario. While the details of the hypothetical program have not been established, it is assumed that the program would function most similarly to a target-price-deficiency-payment program. However, payments would be based on actual production, and the program would feature no "set aside" requirements. The key factor is that the program would truncate the bottom of the distribution function of prices expected by producers. In regards to the target price, it is also assumed that it would not be adjusted each year to reflect increased production costs, but would only be adjusted intermittently over the long-run. U.S. farm policy tends to change only when a Farm Bill is up for revision, and not all crop programs are revised in each bill. It is assumed that any government target price would be based on Salinas Valley production costs, since the Salinas Valley represents a large portion of U.S. production, and would tend to have higher costs than Arizona. Therefore, a government target price would need to be based on Salinas Valley data in order to provide a suitable safety net. It is assumed that Salinas Valley harvest costs are representative of the U.S. lettuce industry, because they are made up of costs that tend to be very similar between Arizona and California, which produce 96% of U.S. lettuce.

The assumptions preclude those producers, who have higher than average production costs, and therefore cannot secure forward contracts, or must do so at a loss. The scope

Table 3. Summary of Simulated Net Income Results

Salinas Valley Head Lettuce Model 2003-2012
Net Income per Acre
Based on 100 Iterations Each Year Under Three Different Scenarios:

1) **Cash Marketing**
2) **100% Forward Contracting (Contract Price is set at 3% above expected Cost of Production)**
3) **A Target Price Policy (Target Price is set at 85% of California Production Cost in 2003, which is $18.71/Cwt.)**

Summary of Net Income ($/Acre)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Probability ≤ 0 Under Cash Marketing	54%	69%	76%	72%	71%	67%	65%	71%	73%	71%
Probability ≤ 0 Under Contracting	31%	32%	48%	37%	40%	27%	38%	38%	36%	33%
Probability ≤ 0 Under Price Support	36%	53%	62%	59%	69%	72%	66%	67%	67%	73%
Probability > 0 ≤ 500 Under Cash Marketing	11%	7%	5%	5%	3%	8%	8%	1%	6%	6%
Probability > 0 ≤ 500 Under Contracting	37%	32%	37%	43%	34%	44%	35%	36%	34%	28%
Probability > 0 ≤ 500 Under Price Support	24%	19%	21%	20%	17%	14%	13%	13%	10%	7%
Probability > 500 Under Cash Marketing	35%	24%	19%	23%	26%	25%	27%	28%	21%	23%
Probability > 500 Under Contracting	32%	36%	15%	20%	26%	29%	27%	26%	30%	39%
Probability > 500 Under Price Support	40%	28%	17%	21%	14%	14%	21%	20%	23%	20%
Maximum Under Cash Marketing	$4,916	$6,007	$9,019	$7,919	$4,840	$10,277	$7,505	$8,940	$6,433	$9,682
Maximum Under Contracting	$1,409	$1,957	$1,388	$1,626	$1,574	$1,669	$1,830	$1,597	$1,807	$1,658
Maximum Under Price Support	$4,916	$4,702	$7,696	$4,367	$4,119	$7,042	$5,391	$7,725	$5,630	$7,152
Minimum Under Cash Marketing	($3,199)	($3,214)	($3,729)	($2,783)	($3,656)	($3,995)	($3,614)	($3,796)	($4,022)	($3,827)
Minimum Under Contracting	($927)	($1,472)	($1,641)	($1,954)	($1,197)	($1,130)	($1,520)	($1,116)	($1,339)	($1,642)
Minimum Under Price Support	($1,207)	($1,884)	($1,958)	($2,482)	($1,860)	($1,917)	($2,447)	($2,361)	($2,404)	($2,888)
Expected Value Under Cash Marketing	($3)	($441)	($731)	($547)	($685)	($340)	($333)	($393)	($701)	($576)
Expected Value Under Contracting	$239	$202	$29	$86	$169	$278	$191	$141	$192	$278
Expected Value Under Price Support	$602	$198	$103	$20	($172)	$0	($31)	$4	($123)	($142)

of this project does not empirically examine the effects of contracting only a portion of a firm's production. The model designed in this research estimates net income based on certain information that is specific to the Salinas Valley, therefore alterations would have to be made before utilizing the model to estimate net income of producers in other geographic areas.

The results are based on assumed levels of contract and government target prices. Any changes to those assumptions can greatly affect the results. For ease of reading, the explanations given below are written as if they encompass all derivations of forward contracting and price support. Therefore the reader is advised to apply the following phrase when examining reported results, "At the given levels of contract and government target prices". In other words, while this phrase is not explicitly used in all discussion of results, it is assumed.

General observations from results are as follows:

- Forward contracting versus cash marketing reduces the probability of losing money by approximately 50% each year.
- A probability of losing money under contracting still exists, due to unexpected drops in yield.
- Government support versus cash marketing reduces the probability of losing money by 10-15% in early years.
- Under cash marketing growers tend to either lose money or make at least $500/acre in any given year, with a small probability of making between $0 and $500.
- In all years but the first, there is greater probability of making at least $500/acre under either cash marketing or contract pricing versus government support.
- In general, contracting does not reduce the probability of making at least $500/acre.
- The potential maximum net income under cash marketing exceeds that of the other two scenarios in all years but the first.
- The potential maximum net income under government support exceeds that available under contracting in any given year.
- The potential minimum net income is smallest under cash marketing in any given year.
- The potential minimum net income is greatest under contracting in any given year.
- Variability in price is greatly reduced under contracting.
- Producers are expected to lose money in every year under cash marketing.
- Producers are expected to make money every year under contracting.
- Producers are expected to lose money in four out of ten years under government support.

On average, it appears that producers maximize total returns by utilizing forward contracts. However, forward contracts do limit the upside price potential. The less risk-averse producers may or may not be better off from year to year utilizing forward contracts. Therefore, risk-averse producers appear better off utilizing forward contracts, while less risk-averse producers might prefer to use a combination of both contracts and

free market scenarios. The results also confirm the grower panel's suggestion that without forward contracts most growers would financially fail.

In general the results suggest that lettuce producers selling in the cash market would gain from a government safety net designed in this fashion. Upside potential in price under the government safety net scenario is reduced, but downside risk is also reduced. On the average, producers would have greater returns with this type of government support versus having no support or contracts.

The results in Table 3 indicate that in general, forward contracting optimally mitigates price risk, by maximizing profitability per acre. However, in order to more clearly present results, the total 10-year estimated net income under each scenario was simulated. The cumulative distribution functions (CDF's) for estimated 10-year net income are shown in Figure 1.

Figure 1. Cumulative Distributions for Simulated 10-Year Net Income Per Acre

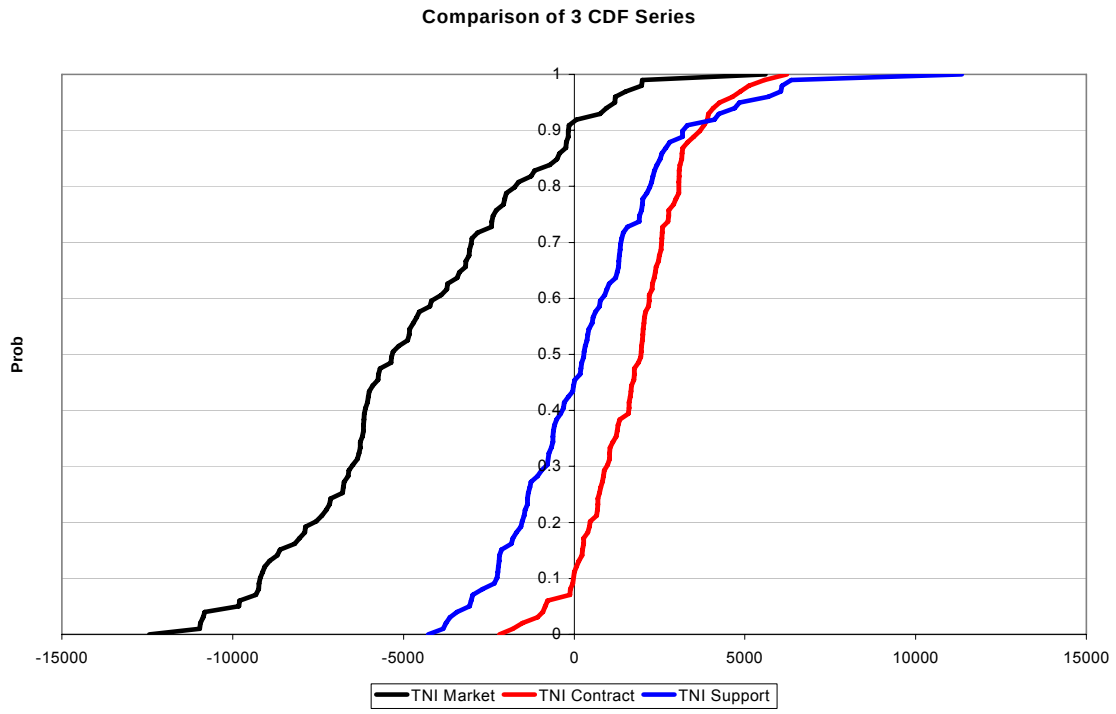

Figure 1 clearly indicates that at each probability level, producers are expected to make the least amount of profit under the cash marketing scenario. Over the 10-year period producers are expected to have approximately a 10% chance of being profitable using cash market pricing. Producers are expected to have a 90% probability of being profitable using forward contracts, and a 45% probability of being profitable with the hypothetical government support.

Figure 1 also indicates that there is approximately a 92% probability of making a greater profit under the contracting scenario versus the government support scenario. However, the upper tail of the CDF for the government support scenario extends much further to the right, and therefore maximum potential is greater using the government support.

Therefore, it is plausible that a producer with an extremely high risk-preference might prefer the government support scenario over the forward contracting scenario. In an attempt to reconcile this observation, a Stochastic Dominance with Respect to a Function (SDRF) process was used. The expected differences in net income between the contracting scenario and the government support scenario at each probability level were weighted using a Risk Aversion Coefficient (RAC) and then summed. The RAC level in question was that of a highly risk-preferring Salinas Valley lettuce producer. Pratt defines the coefficient of absolute risk aversion of a set of producers (r(x)) as the ratio of the second and first derivatives of the growers' utility function, or $r(x) = -u''(x)/u'(x)$.

Since the utility function with respect to profit for Salinas Valley lettuce producers was unknown, the absolute RAC level of Salinas Valley producers was estimated using a procedure suggested by McCarl and Bessler. The estimated RAC was found using the formula: 2*(Coef. of Var.)/Std. Dev. The coefficient of variation and standard deviation used were from the distribution of 10-year net income under the government support scenario. The formula yielded an estimated RAC of .15. Anderson and Dillon suggest that as a rule of thumb, the RAC of a more risk preferring group of producers can be estimated as one half that of the general RAC level. Therefore, the RAC used in this comparison was .075. Using the SDRF procedure, it was found that even at low levels of risk preference (RAC .075), total utility was still greater under the forward contracting scenario.

Conclusions and Implications

Price risk continues to have a significant impact on the management and marketing strategies used by Salinas Valley lettuce producers. The prevalence of forward contracting has contributed to thinner cash markets and has therefore lead to greater spot price variability. Government mechanisms to mitigate price risk for commodity producers have been widely used, however specialty crop producers have historically used market mechanisms to manage price risk. These factors have fueled the use of forward contract pricing by Salinas Valley lettuce producers as a means to manage that risk. While forward contracting does limit downside risk, it adds the risk of producers being excluded from receiving higher prices in times of price spikes.

An econometric framework was used to estimate the future pecuniary benefits and costs of contract pricing versus cash market pricing and other risk-mitigating mechanisms. Results indicate that Salinas Valley lettuce producers should maximize profitability by using forward contracts. In the long run, cash marketing is clearly First-Order Stochastically Dominated by both forward contracting and the hypothetical government program.

Salinas Valley lettuce producers must continually make management decisions that affect the profitability of their firms. As forward contracting becomes an increasingly preferred choice by these producers, they are left to question the specific costs and benefits of doing so. In addition, while many Salinas Valley lettuce producers claim that a government support program would make them less profitable, they have little empirical evidence to support that claim.

The implications of the results of this research are positive for Salinas Valley lettuce producers who continue to secure forward contracts. However, the results suggest that

those producers who cannot or will not secure forward contracts may face financial difficulty. The results of this study reinforce the importance of cost efficiency, since lower costs allow for more competitive contract prices, while still remaining profitable. The results also offer empirical evidence that Salinas Valley lettuce producers should continue to favor the market mechanism of contract pricing, as opposed to a governmental support program like the one considered here. Producers should work hard to establish/maintain contractual relationships, and should work to improve the terms of these contracts. The results from this study can assist many fresh-market fruit and vegetable industries in making more informed decisions on preferred marketing methods.

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Endnotes

[1]Specialty crops are defined as fruit, vegetable, nut, nursery, and certain animal products (California Institute for the Study of Specialty Crops).

[2]Flat pack, naked head lettuce refers to lettuce that is packed unwrapped and placed into the carton without any separators between heads.

[3]Independent variables: EP_t is expected U.S. grower price in time t; HA_{t-1} is U.S. harvested acreage in time t-1; Trend is a yearly counter; P_r is the U.S. retail lettuce price; P_r^2 is the U.S. retail lettuce price squared; P_t is U.S. grower price in time t; and Ln Trend is the natural log of the yearly counter.

References

Anderson, J.R., and J.L. Dillon. *Risk Analysis in Dryland Farming Systems*. Farming Systems Management Series No. 2, FAO, Rome, 1992.

Baires, Filadelfo, and Tom Clevenger. "The Propensity to Excess Capacity in the Lettuce Subsector." *Western Journal of Agricultural Economics* (June 1977):161-165.

Boehlje, Michael. "Risk in U.S. Agriculture: New Challenges and New Approaches." Staff paper 02-07, Department of Agricultural Economics, Purdue University, November 2002.

Bunn, Chris, Bill Munger, Nichole Souza, and Bill Tarp. Grower/Shipper Panel Discussion, Salinas (August 2004).

Bunn, Chris. President, Crown Packing Company, Inc. Personal Interview, Salinas (July 2004).

Carriquiry, Miguel, and Bruce A. Babcock. "Can Spot and Contract Markets Co-Exist in Agriculture?" Working paper 02-WP 311, Center for Agricultural and Rural Development, Iowa State University, August 2002.

Cowan, Robin, and Philip Gunby. "Sprayed to Death: Path Dependence, Lock-in and Pest Control Strategies." *The Economic Journal* 106(May 1996):521-542.

Glaser, Lewrene, Gary Lucier, and Gary Thompson. "Lettuce: In and Out of the Bag." *Agricultural Outlook*. Washington D.C.: Economic Research Service, U.S. Dept. of Agriculture, April 2001.

Glaser, Lewrene K., Gary D. Thompson, and Charles R. Handy. *Recent Changes in Marketing and Trade Practices in the U.S. Lettuce and Fresh-Cut Vegetable Industries*. Washington D.C.: Economic Research Service, U.S. Dept. of Agriculture. Information Bulletin No. 767, May 2001.

Grower's Express, Inc. "Weekly Salinas Supply and Price Tabulations." Unpublished summary, Salinas (July 2004).

Hamilton, Lynn. AGB 543 – Agricultural Policy and Program Analysis. Class notes and discussion. California Polytechnic State University, Winter 2004.

Hammig, Michael D., and Ron C. Mittelhammer. "An Imperfectly Competitive Market Model of the U.S. Lettuce Industry." *Western Journal of Agricultural Economics* (July 1980):1-12.

Jackson, Louise, et al. *Iceberg Lettuce Production in California*. Vegetable Research and Information Center. Vegetable Production Series. Publication 7215. University of California, Division of Agriculture and Natural Resources, 1996.

Knutson, Ronald D., et al. *Agricultural and Food Policy*, Fourth Edition. Prentice Hall, Upper Saddle River, NJ. 1998.

Lin, William, et al. *Supply Response Under the 1996 Farm Act and Implications for the U.S. Field Crops Sector*. Washington D.C.: Economic Research Service, U.S. Dept. of Agriculture, Technical Bulletin No. 1888, 2000.

McCarl, B.A., and D. Bessler. "Estimating an Upper Bound on the Pratt Risk Aversion Coefficient When the Utility Function is Unknown." *Australian Journal of Agricultural Economics*, 33(1989):56-63.

Menkhaus, Dale J., et al. "Supply and Demand Risks in Laboratory Forward and Spot Markets: Implications for Agriculture." Journal of Agricultural and Applied Economics, 32,1(April 2000):159-173.

Miller, Allen, et al. "Risk Management for Farmers." Staff paper 04-11, Department of Agricultural Economics, Purdue University, September 2004.

Molina, Ignacio. Research Associate, National Food and Agricultural Policy Project, Arizona State University. Personal Communication, July 2004.

Monterey County Agriculture Commissioner's Office. *Monterey County Crop Report 2002*. Salinas, California, 2003.

Monterey County Agriculture Commissioner's Office. *Monterey County Crop Report 2003*. Salinas, California, 2004.

National Food and Agricultural Policy Project. *U.S. Head Lettuce Supply and Utilization Model*. Arizona State University, 2003.

National Food and Agricultural Policy Project – U.S. Head Lettuce Supply and Utilization Results. Internet Site: http://nfapp.east.asu.edu/Outlook04/Page%2043.htm (Accessed April 7, 2004).

Penson, John B. Jr., Oral Capps Jr., and C. Parr Rosson III. *Introduction to Agricultural Economics*, Third Edition. Prentice Hall, Upper Saddle River, NJ. 2002.

Peterson, E. Wesley F. *The Political Economy of Agricultural Natural Resource, and Environmental Policy Analysis*. First Edition. Iowa State University Press, Ames, Iowa, 2001.

Pratt, J.W. "Risk Aversion in the Small and the Large." *Econometrica*, 32 (1964):122-136.

Ray, Daryll E., et al. "Estimating Price Variability in Agriculture: Implications for Decision Makers." *Journal of Agriculture and Applied Economics* 30(July 1998):21-33.

Richardson, James W. Co-Director, Agricultural and Food Policy Center, Texas A&M University. Personal Interview, College Station (March 2004).

Richardson, James W. *Simulation for Applied Risk Management with an Introduction to the Excel Simulation Add-In: Simetar*. Department of Agricultural Economics, Texas A&M University. January 2004.

Roberts, Michael J., Craig Osteen, and Meredith Soule. *Risk, Government Programs, and the Environment*. Washington D.C.: Economic Research Service, U.S. Dept. of Agriculture, Technical Bulletin No. 1908, March 2004.

Tourte, Laura, et al. *Sample Production Costs for Wrapped Iceberg Lettuce: Monterey & Santa Cruz Counties 2000-2001*. University of California Cooperative Extension, 2002.

USDA. *2002 Census of Agriculture County Profile: Monterey, California*. California Agricultural Statistics Service, 2003.

USDA. *2002 Census of Agriculture State Profile: California*. California Agricultural Statistics Service, 2003.

USDA – National Agriculture Statistics Service. Internet Site: http://www.nass.usda.gov:81/ipedb/ (Accessed April 7, 2004).