A Market Example and Economic Evaluation Of Information and Price Uncertainty

by

Stuart Nakamoto
Assistant Professor
Department of Agricultural and Resource Economics
College of Tropical Agriculture and Human Resources
University of Hawaii

John Halloran
Assistant Professor
Department of Agricultural and Resource Economics
College of Tropical Agriculture and Human Resources
University of Hawaii

John Yanagida
Chair and Professor
Department of Agricultural and Resource Economics
College of Tropical Agriculture and Human Resources
University of Hawaii

PingSun Leung
Associate Professor
Department of Agricultural and Resource Economics
College of Tropical Agriculture and Human Resources
University of Hawaii

Abstract

In Hawaii, marketing and production conditions have led to shrinking market shares for local farm produce. The primary limiting factor to maintaining and expanding the market share of Hawaii-grown produce is inconsistent and unreliable supply, compounded by inadequate market coordination.

Supply problems are reflected in and aggravated by variable and uncertain prices. The Hawaii Agricultural Statistics Service (HASS) conducted a pilot program involving the collection and dissemination of expected and actual planting and harvesting information on head cabbage. HASS in turn processed and summarized the information for access by the public. The intent was to reduce the supply and price variability/uncertainty problems through added market information. The objective of this paper is an *ex-post* evaluation of the HASS program, with respect to variability and uncertainty of price. The procedures are twofold. First, price variability is evaluated over two time periods: prior and during the program. Variability is measured by descriptive statistics such as coefficients of variation and other measures of dispersion. Second, price uncertainty is measured in terms of the variance of the residuals of an ARIMA procedure applied to each of the two time series. The F-test is then used to compare relative price uncertainties between periods. Results suggest price variability was reduced, but not price uncertainty. System design seems crucial to determine whether added information leads to a reduction in price variability and uncertainty. In addi-

tion, the method of analysis demonstrates the applicability of ARIMA as an evaluation tool.

Introduction

In October of 1983, the U.S. Department of Agriculture, Statistical Reporting Service and the Hawaii Agricultural Reporting Service (now Hawaii Agricultural Statistics Service - HASS) in cooperation with the Hawaii Farm Bureau initiated an information collection and dissemination program (officially called the "Vegetable Grower Production and Acreage Survey"). The program was intended to assist Maui producers and local marketers in making better production and marketing decisions. The overall objective of this study is to evaluate the impact of that program in reducing price uncertainty.

Hawaii's producers of most vegetable crops face what is commonly referred to as a pocket market (Peters et al.). A pocket market is characterized by limited size and accentuated by the lack of market alternatives. Under such conditions, unexpected changes in local supply can dramatically affect the price farmers receive. In Hawaii, the pocket market is exacerbated by the actual as well as potential presence of mainland imports, which reduces the local farmers' bargaining position and increases the complexity of their own production and marketing decisions. As expected, mainland imports exert downward pressures on local prices.

Producers, represented through the Hawaii Farm Bureau, believed the problem was related to: a) a lack of accurate and timely information on the part of local producers about cabbage plantings and harvest; and b) the lack of accurate and timely knowledge on the part of wholesalers regarding expected harvests and hence, their over-reliance (from the local producers' perspective) on mainland produce. They felt that if local market participants had better information regarding local acres planted, expected harvest, and actual sales on a timely basis then much of the fluctuation in local supply and price could be reduced.

Production and market supply of head cabbage has increased little over the past decade, generally at a slightly lower rate than population growth. In terms of volume, head cabbage is the #1 vegetable crop grown in the state. The 1987 harvest of 15 million pounds had a farm gate value of $2.2 million. Although 60 percent of Hawaii's market supply of all fresh vegetables is imported, Hawaii production accounted for 99 percent of head cabbage in 1987. Figure 1 illustrates the behavior of prices over the time period covered by this study.

Head cabbage growers in Maui, where approximately 80 percent of the state's production is located, have faced a pocket market for years. It often resulted in extended periods of severely depressed prices. Due to the relatively small size of the market, unexpected increases in local production often resulted in market gluts and hence, low prices.

The system operated by HASS collected three basic pieces of information from virtually every commercial head cabbage producer on Maui. Each Monday, farmers phone in their: a) production from the previous week, expected production for the current week, and expected production for next week; b) sales from the previous week; and c) acres planted and harvested from the previous week.[1] This information was then aggregated, put on a code-a-phone tape and made available to the public. A sample message is shown below.

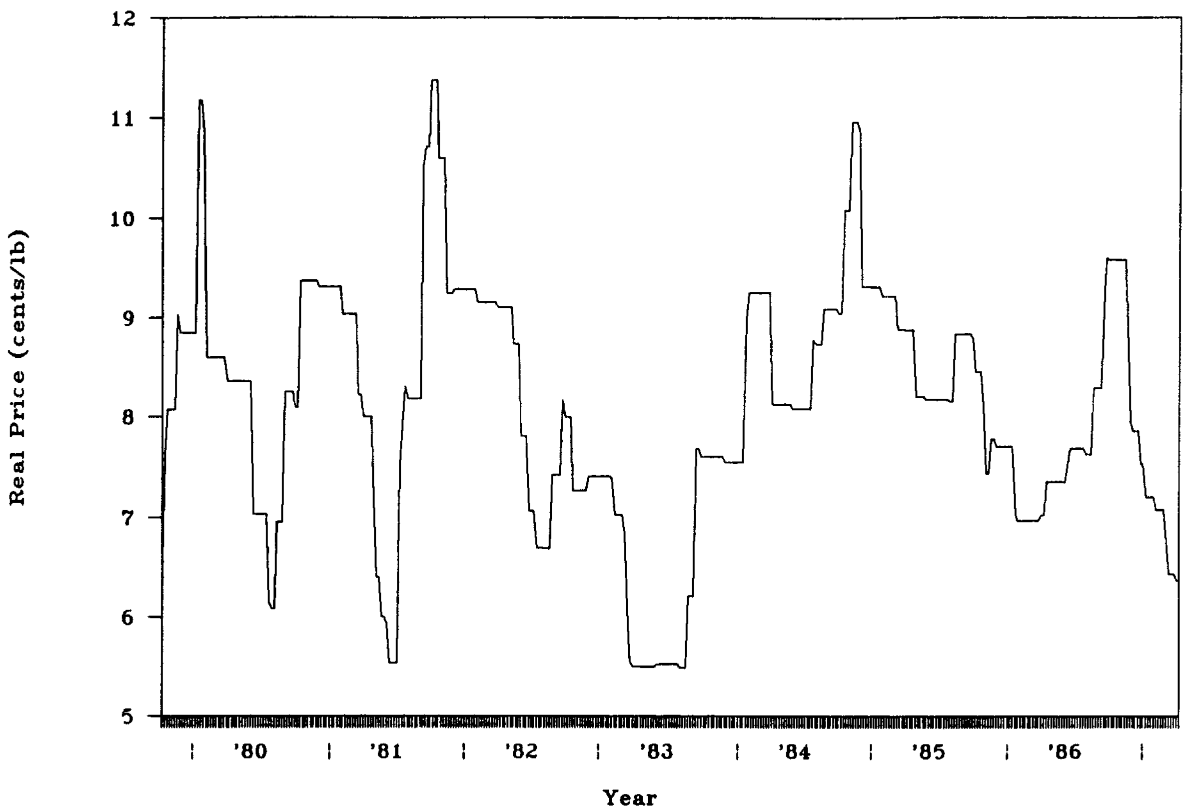
> This is the Hawaii Agricultural Statistics Service with production and acreage summaries for Maui head cabbage. Last week's production of head cabbage from Maui is estimated at 300,000 pounds. 288,000 pounds is forecast for this week with production decreasing to 275,000 pounds next week. Farmers reported fresh sales of 290,000 pounds for the week ending [date] with a marketable loss of 70,000 pounds. During the same week, farmers planted 10.5 acres and harvested 11 acres.
>
> Thank you for calling the HASS/ Farm Bureau 24-hour vegetable telephone line.

It was hypothesized that producers' use of the information would help coordinate planting and marketing decisions and prevent mistakes of over-production which cause market gluts. It was also hypothesized that the wholesalers' use of the information would improve the price situation.

Objectives

The primary objective of this research is to ascertain the information program's impact on prices received by Hawaii's head cabbage producers. Market price has been chosen as the variable of study because it is the most visible

Figure 1. Weekly Head Cabbage Prices.



variable facing producers and marketers. It is reasonable to assume that if there were any significant changes in the pattern of plantings and/or weekly deliveries, these changes would be translated into a change in the pattern of prices observed. It also assumed that if the program is successful a higher mean price will probably be observed during the program's operation as producers would find easier access to the market and be better able to avoid overproduction and subsequent periods of depressed prices.

Two key parameters of price will be examined, variability and uncertainty. The variability of price can be measured as the degree of variation around the mean (Sarwar and Anderson). Variability, in and of itself, is neutral. Difficulty arises when variability is not known with certainty. It is the uncertainty component in variability which causes problems for decision makers. For example, cabbage farmers are uncertain about how much acreage their neighbors are planting and thus are uncertain of the price they will receive in three months. However, if variations in planting and thus price were known with certainty, farmers would have less problem in dealing with this variability.

Method of Analysis

Variability of Prices

Bi-weekly real wholesale prices for head cabbage in the Honolulu market as reported by the Hawaii Market News Service are used in this analysis. Bi-weekly prices were selected because weekly price quotes exhibited extreme "stickiness." Although farm-level prices are preferred to wholesale level prices, a consistent series was not available. However, given pricing practices and market share, wholesale prices provide a good proxy. The analysis covered the time period October 1979 to April 1987. The series was broken into two sub-periods: October 1979 to September 1983 representing the period before the initiation of the program; and October 1983 to April 1987 representing the period during the program's operation.

Two methods of analysis were employed. First, descriptive statistics were used for exploratory purposes and for numerical comparisons of the variables between the periods before and during the program. Means and standard deviations were also noted. Second, differences in the standard deviations (via the variance) from the prior period to the program period were tested using an F-test (Snedecor and Cochran). Based on the results of this test, differences in the means were tested with a t-test under the assumptions of equal or unequal variances. With unequal variances, Satterthwaite's approximation was used for degrees of freedom (SYSTAT).

The coefficient of variation, expressed as a percentage, was also calculated to compare the relative relationship between level and variability over time. In general, the coefficient of variation with a successful program was expected to decrease, indicating a relative increase in the price level and/or a decrease in its dispersion (increase in stability).

Since the above analyses, in particular the t-test, assume independence of the two samples as well as independence within each sample, a more appropriate method is to use autoregressive integrated moving average models (ARIMA) to evaluate the behavior of price and its parameters between the two periods.[2] ARIMA identifies the systematic variation in a time series and uses this systematic random component to forecast or backcast the series.[3] It can also be used to measure the variance of this random component.

Uncertainty of Farm Prices

Price variability as defined above is not necessarily indicative of unpredictability and uncertainty. To be indicative, the stochastic behavior of prices must vary randomly around a constant mean. If prices are autocorrelated, the above measure of price variability would tend to exaggerate price unpredictability. If prices are autocorrelated, it is expected that market participants would incorporate this information into their decision-making process, so the autocorrelation would not lead to increased price uncertainty.

Since it is highly likely that prices are autocorrelated, ARIMA is a more appropriate method for evaluating uncertainty as it too makes use of the information embodied in the autocorrelation. ARIMA is a method which can account for autocorrelation and has been shown by Bessler (1980) to correspond with aggregate personalistic probability distributions--how farmers form their price expectations. ARIMA has found wide use in monetary economics and investment analysis in identifying the basic process of price formation. This analysis uses ARIMA techniques to identify the price expectation models for bi-weekly wholesale cabbage.

The data series modeled is identical to that used in the examination of price variability. The autocorrelation and partial correlation for each sub-period were examined. The residuals from the identified ARIMA model(s) are then used to measure price uncertainty. In this measure, the variance of the ARIMA residuals are calculated. An F-test was then employed to compare the relative price uncertainty of the pre- and during-the-program periods.

Results

Variability of prices

The results of the bi-weekly price variability are presented in Table 1. A statistically significant decrease in the variability of prices was found to have occurred from the pre- to the during-period.

As was expected, the variability, as measured by the variance and the coefficient of variation, decreased from the pre- to the during-period. Also notable was the increase in the mean price (in real terms) from the pre- to the during-period.[4]

Although these results are suggestive that the program had the hypothesized impacts, it must be remembered that if the observations are autocorrelated these estimates are suspect. Thus, we must examine the results from the ARIMA analysis to substantiate these results as well as determine the program's impact on price uncertainty.

Price Uncertainty

Following the model building process described by Box and Jenkins which involve steps for identification and estimation, ARIMA models were identified for the bi-weekly data series covering the two time periods (see Table 2). No seasonal effects were found. Both models are identical, and characterized by large and statistically significant autoregression terms (asymptotic standard errors of the parameter estimates are shown in parentheses). A diagnostic check (Q-statistic) showed that the hypothesis that the residual correlations are based on white noise cannot be rejected.[5]

The results suggest the notion that price formation is highly dependent on past prices throughout both time periods. The models show that a $1 increase (decrease) in price in period t-1 is likely to result in a $0.998 price increase (decrease) in period t. The identical models for the periods suggest the underlying stochastic process has remained unchanged by the program's adoption.

The variance of the residuals generated from the ARIMA models in the pre- and during-periods are given in Table 3. The results do not lend support to the hypothesis that the program was able to reduce price uncertainty.

Summary and Conclusions

The ARIMA results indicate that the program had no discernible impact on price uncertainty, although descriptive statistics suggest it did increase mean price and ameliorate price variability.[6] Perhaps uncertainty was already minimized. Intuitively and theoretically, the ARIMA results otherwise run counter to expectations. That is, additional information should reduce uncertainty. However, this hypothesis contains two implicit assumptions about the information. First, the additional information was an improvement over the existing informational base and second, decision makers were aware of and made use of the information.

Both assumptions can be questioned in this case. Because cabbage production on Maui is concentrated within a small geographical area and among relatively few farmers, producers may have already exchanged this information on an informal basis. Thus, the system may have simply formalized this activity.

An important component expected to contribute to the program's success was its use by local wholesalers to adjust their ordering policy. However, an informal survey of Honolulu wholesalers indicated that they were almost totally unaware of the system's operation and purpose. They continued business as usual.

The wholesalers' role is nevertheless intriguing in light of the low percentage of imports. Can producers unilaterally affect price, and to a different extent, than if more products were imported? Further research will address this issue.

Another possible explanation for the lack of impact is that the data used did not reflect the effect of the program. Two other variables which will be examined in the future are weekly deliveries (unloads) and gross revenues as measured on the wholesale level. Although it is logical to expect that production patterns would be reflected in prices, the direction of causality must be investigated as well as para-

Table 1. Price Variability Comparisons for Cabbage, Pre- and During Operation of Information Program

Variable	Pre-	During	T-Value F-Value	Table Value
Mean	7.932	8.250	2.509	1.645
Variance	2.0164	0.8742	2.307	1.332
Coefficient of Variation	17.9	11.3	-	-

Table 2. Cabbage Prices, ARIMA Models: Pre- and During Information Program

Period	Model	Parameter Estimates	Q-Statistic*
Pre-Program (October 1979 to September 1983)	$P_t = \phi_1 P_{t-1}$	$\phi_1 = 0.998$ (0.011)	16.93
During Program (October 1983 to April 1987)	$P_t = \phi_1 P_{t-1}$	$\phi_1 = 0.998$ (0.011)	4.87

*$\chi^2_{.05}$ and $\chi^2_{.01}$ (d.f.=25) are 37.65 and 44.31.

Table 3. Price Uncertainty Comparisons Between Pre- and During Program

Variable	Pre-	During	F-Value	Table Value
Variance of ARIMA Residuals	0.774	0.7674	1.009	1.332

meters of market structure which could have obscured the impact of the program.

Endnotes

[1] Those farmers who do not phone in their information are contacted by a HASS representative.

[2] Numerous textbooks discuss the ARIMA procedure including Box and Jenkins, Nelson, and Pindyck and Rubenfeld.

[3] ARIMA models are built upon and forecast on the basis of past observations of the variable in question. The ARIMA technique differs from econometric methods in that no theoretical structure is imposed. In many ways it is the classic black box.

[4] Although there are statistically significant differences, this analysis alone cannot lead to the conclusion that such changes were caused by the program. History effects--the possibility that changes attributed to the program are actually indicative of other factors--need to be addressed. To compensate for the lack of a true quasi-experiment, Nakamoto proposed using a "pseudo-quasi-experiment" by comparing head cabbage to a similar crop. See Nakamoto, Stuart T., "The Impact of Information on a Market for Head Cabbage & Head Lettuce in Hawaii." Unpub. Ph.D. dissertation in Agricultural & Resource Economics, University of Hawaii, Dec. 1986.

[5] To determine the "best" model, other ARIMA models were also identified and estimated. Comparing autocorrelation and partial autocorrelation functions and calculated Q-statistics, Table 2 results were deemed "best." A reviewer also suggested modelling shorter time periods after inception of the program to check for effects of information aggregation over time. Coefficients (standard errors in parentheses) were 0.998 (0.038) for one year, and 0.944 (0.018) for two years.

[6] Again, other possible causes have not been excluded. See endnote 4.

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