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# The Rationality and Price Effects of U.S. Department of Agriculture Forecasts of Oranges

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## ABSTRACT

This article examines the effect of public information on the orange juice market. We investigate the rationality, information content, and price effects of U.S. Department of Agriculture forecasts of the production of oranges. U.S. Department of Agriculture forecasts are found to be unbiased and efficient. The first forecast contains the most new information, and subsequent reports become valuable only when freezes occur. Significant price movements occur in response to announced production in both Florida and California. However, the majority of price variations cannot be explained by these movements in supply.


*We are always talking about overproduction. There would not be any overproduction if we could get these oranges at a decent price to the people who ... could use them. The children need them; they have so many vitamins. By keeping the price way up nobody can buy them and God knows, we get nothing for them. I sold my Valencias for 10 cents a box. I was offered 50 cents, and I thought I would hold out a little until I finally sold them for 10 cents.*[1]

IN HIS SEMINAL ARTICLE, Roll (1984) studied the extent to which daily variation in frozen concentrated orange juice (FCOJ) futures prices were explained by weather and other public information. Rainfall and temperature in the growing area, as well as news stories about U.S. Department of Agriculture (USDA) crop forecasts, domestic demand, and foreign supply and demand were all used as explanatory variables, but no factor could be identified that explained "more then a small part of the daily price movement." A rapidly expanding theoretical literature has been developed to explain Roll's and others' empirical observations that public information is less important than private information in explaining market price movements. These models, which fall under the general heading of "noise trading," assume that some market agents may not be rational, and that market prices have fad or bubble components.[2]

* The Department of Economics, Iowa State University. We are indebted to Ronald Ward, who provided data on orange juice futures prices, and to Richard Allen and members of the National Agricultural Statistical Service, who helped locate the data on USDA forecasts. Helpful comments and suggestions were received from Mark Brown, Barry Falk, Robert Terry, Ronald Ward, and a referee. Angela Jewett and Sue Streeter prepared the manuscript.

[1] Statement of citrus farmer Mrs. Beulah Hooks Hanna of Lakeland, Florida to a Subcommittee of the U.S. Senate Committee on Agriculture and Forestry (1948) p. 64.

[2] See Shleifer and Summers (1990) for a review of noise trading.

By focusing on private or individual beliefs and motivations not justified by fundamentals, the noise-trading viewpoint calls into question the role and importance of public information collection and dissemination. If private beliefs are the dominant forces affecting market prices, then government efforts to provide common information may be a waste of resources. Market agents could already have fully anticipated the public information by the time the "news" is released. On the other hand, the "news" contained in public information may depend on the timing, the rationality, and the type of public information released.

This article examines these questions by studying USDA forecasts of Florida and California orange production. It extends Roll's analysis by focusing exclusively on releases of public information about orange production, as opposed to weather, and by trying to ascertain the time of year when this information is most useful to market agents. Weather is an input into orange production, but it is difficult to draw a direct inference from a change in the temperature to a change in harvest size. A temperature drop from 90 to 75 degrees may have no effect on production, but the change from 33 to 32 degrees may have a dramatic effect. Thus, public weather information may only affect prices on days when weather affects production. This ambiguity is removed when production information is examined directly. As Ms. Hannah's statement indicates, the supply of oranges has long been perceived as an important determinant of orange prices. Therefore, USDA production forecasts should alter prices, unless the forecasts are fully anticipated by market agents. Our strategy is to concentrate on those days when this production news ought to be important and to see if private information still is the dominant force moving market prices.

Section I contains a description of the market for oranges and orange products. An explanation of the data and the empirical strategies used in this article are in Section II. Section III reports the empirical tests of rationality and informational content of USDA forecasts. Estimates of the price response to the USDA forecasts are reported in Section IV. We summarize our findings in Section V.

## I. The Market for Oranges

Oranges are either sold fresh or are processed into juice and concentrate. Because of variety differences and a higher profit margin from fresh produce, only a few world areas specialize in growing oranges purely for processing. The most important areas are Sao Paulo, Brazil, and Florida. Most of the world's processed citrus juices come from those two areas with the United States consuming about fifty percent of the supply. Estimated free on board value of U.S. oranges at processing plants totaled \$3.8 billion for the 1988 to 1989 crop year.[3]

[3] Ward and Kilmer (1989) provide an extensive review of world orange production and marketing. See, in addition, Food and Agriculture Organization of the United Nations (1989). Dr. Mark Brown of the Department of Citrus, University of Florida, Gainesville, Florida, also provided some of this information.

The FCOJ market is particularly interesting for the study of market responses to public production forecasts for two reasons. First, the market is relatively free and competitive, since the government does not intervene in the production and processing of oranges. Federal and state marketing orders do exist for oranges, but they provide no direct control over the price or volume of oranges used for processing. Therefore government intervention will not alter the price response or change the incentives for market agents to collect information, as might be true for other agricultural commodities.

Second, in years of normal weather, the vast majority of U.S. orange production for processing takes place in central Florida. This geographic concentration is highly unusual compared with other agricultural commodities. Oranges are also produced in large quantities in California, but weather and variety differences combine to make California oranges more valuable as fresh produce, while Florida oranges are more suitable for concentrate.[4] This geographic concentration of production should increase the accuracy of the monthly crop forecasts. On the other hand, the concentrated production also would make it easier for private agents to gather the information.

A common problem in demand estimation is the simultaneous determination of supply and demand. With price response defined as the price change from the day of the crop forecast to the day after, the time period is short enough for demand to be assumed constant. In this study, reverse causality is not a problem, since the USDA production forecast can be viewed as a pure supply shock. We can also determine if USDA forecasts of California orange production move FCOJ prices. Significant cross-price effects would be evidence of substitutability or complementarity in the underlying demand for California (fresh) and Florida (frozen concentrate) oranges.

## II. Data and Empirical Strategies

The crop year for oranges begins July 1 of each calendar year and ends the following June 30. The USDA issues monthly crop reports of citrus production beginning in October and continuing through the following July when a "final" estimate of crop size is issued.[5] This study examines forecasts of supply for four varieties: Florida Valencia, Florida Early, California Navel, and California Valencia oranges. Immediately after the first of each reporting month, the USDA sends surveys to growers to report their expected production as of the first of that month. These results as well as some first-hand observations are collected and analyzed. The production announcement is

[4]California oranges have a more appealing outer skin texture and are more valuable as fresh produce, whereas Florida oranges are sweeter and make better tasting juice. The lower sugar content of California oranges also give them a longer shelf life in the fresh form.

[5]The final USDA estimate is considered the "true" orange production in the later rationality studies. When USDA revises its final estimates as occasionally happens, that revised figure is used in the analyses. Any revision of the previous July final estimate is usually done in the October report, but the timing of the revision's announcement is not significant here. The data used in this article were obtained from monthly issues of USDA *Crop Production* from October, 1940 to July 1992. No data for earlier years could be found.

made at 2 P.M. (after the futures markets have closed) during the second week of the month.

FCOJ futures contracts were created in 1967 to be the forward pricing mechanism that could protect processors of oranges against the price risk from holding inventories of FCOJ. The price variable used in this analysis is the daily closing price of the FCOJ futures traded on the New York Cotton Exchange.[6] Like most futures, FCOJ contracts have a limit set by the commodity exchange on the amount of price change allowed during one trading session. How to handle these limit moves is an important econometric question. Since the intent of this article is to measure price response to production news, the final value in determining price change is the closing price on the first nonlimit day.

On the announcement day in January, 1981 and January, 1982, FCOJ futures were in the midst of several days of limit moves in response to severe freezes on or just before the USDA report day. These two observations were deleted from the sample, since the price moves were exogenous effects of the freezes and clearly not related to the USDA crop report.

## III. Testing The Rationality and Value of Government Forecasts

Midseason freezes have disastrous consequences for orange production. For example, six times between 1973 and 1991, freezes reduced the Florida Valencia crop at least twenty percent.[7] No amount of good weather the rest of the crop year can overcome the production loss caused by a serious freeze.

Suppose $Q_t$ is the true realization of orange production in year $t$. Let $F_{m,t}$ be the forecast of final orange production if no freeze occurs in year $t$, conditional on information available to the USDA on the first day of month $m$ of year $t$. $F^f_{m,t}$ is the comparable forecast of final orange production if a freeze occurs in year $t$. The expectation of orange production as of month $m$ in year $t$ can be written

$$E(Q_t|\Omega_{m,t}) = (1 - \pi)F_{m,t} + \pi F^f_{m,t} \tag{1}$$

where $\pi$ is the probability of a freeze and $\Omega_{m,t}$ is the information set available at the time of the forecast. The associated forecast error can be written

$$Q_t - E(Q_t|\Omega_{m,t}) = \varepsilon_{m,t} \tag{2}$$

where $\varepsilon_{m,t}$ is a forecast error that has mean zero if the forecast is rational.

[6] We use the "settlement price" of the second nearest delivery month as determined by the Cotton Exchange at the end of each trading day. We are grateful to Dr. Ronald Ward, who supplied most of the futures price data for this study. More recent prices were taken from various issues of the *Wall Street Journal*.

[7] The major freezes for Florida Valencia occurred in January of 1977, 1981, 1982, and 1985 and December of 1983 and 1989. The 1982 and 1983 freezes also severely damaged Florida Early. Both California varieties suffered from a December 1990 freeze.

USDA forecasts are conditioned on information available the first day of each forecast month. If a freeze has not yet occurred by that first day, the USDA announces $F_{m,t}$ on the assumption that no freeze will occur during the remainder of the season.[8] If, by the first of the month, there has been a freeze, the USDA announces the freeze-damaged production forecast, $F^f_{m,t}$.

Suppose freeze-damaged production is proportional to $F_{m,t}$, so that

$$F^f_{m,t} = \delta F_{m,t}, \quad \text{where} \quad 0 < \delta < 1. \tag{3}$$

Substituting equations (1) and (3) into equation (2), and rearranging

$$Q_t - F_{m,t} = -\pi(1-\delta)F_{m,t} + \varepsilon_{m,t}. \tag{4}$$

Equation (4) gives the forecast error from a USDA forecast made conditional on the assumption that no freeze will occur for the remainder of the year. Even though $E(\varepsilon_{m,t}) = 0$, $E(-\pi(1-\delta)F_{m,t})$ is not zero, since $\pi > 0$. As a result, ex post tests of the rationality of early season USDA forecasts will find evidence against the null as long as freeze years are included in the data set.

To illustrate this, consider the regression approximation to equation (4) as given by

$$Q_t = \alpha_0 + \alpha_1 F_{m,t} + \alpha_2 F_{m,t} * FDUM_t + \varepsilon_{m,t} \tag{5}$$

where $\alpha_0$, $\alpha_1$, and $\alpha_2$ are parameters, and $FDUM_t$ is a dummy variable that takes the value of 1 if a freeze occurs in year $t$. If the conditional USDA forecast is rational, $\alpha_0 = 0$, $\alpha_1 = 1$, and $\alpha_2 = -(1-\delta)$. Excluding the dummy interaction term from equation (5) would result in a parameter estimate for $\alpha_1 = [1 - \pi(1-\delta)]$, which only equals 1 if $\pi = 0$. Therefore, tests of the rationality of the USDA forecasts made conditional on the "no freeze" assumption must include a control for the ex post realization of a freeze.

We examine two forms of equation (5). The first is known as the weak-form test of rationality. For this test, we use equation (5) as it is and perform the joint test of the hypothesis that $\alpha_0 = 0$ and $\alpha_1 = 1$. This test is performed over the full sample from 1940 to 1991.

The second form is to specify the error term to include available information as of month $m$ and year $t$. If $\varepsilon_{m,t} = \alpha_3 X_{m-1,t} + \mu_{m,t}$, equation (5) becomes

$$Q_t = \alpha_0 + \alpha_1 F_{m,t} + \alpha_2 F_{m,t} * FDUM_t + \alpha_3 X_{m-1,t} + \mu_{m,t} \tag{5A}$$

where $X_{m-1,t}$ is a vector of market information. Direct estimation of equation (5A) allows a strong-form test of rationality, which requires that $\alpha_0 = \alpha_3 = 0$ and $\alpha_1 = 1$, jointly.

[8]USDA Publication 1308, p. 65, states, "The estimates ... assume normal weather patterns, crop growth and development, and typical harvest losses from the month of forecast until the end of harvest." UDSA official Robert Terry confirmed that the USDA excludes any consideration of historical freeze probabilities from its monthly forecasts. Freeze information is reflected only after the freeze occurs.

For our empirical work, we assumed that the $X_{m-1,t}$ vector included the previous USDA forecast, $F_{m-1,t}$, and the change in futures price level from the close after the previous report to the close just before the current forecast, $\Delta P_{m-1,t}$.

The October report is the first of the crop year, so no previous USDA forecast for the crop year is available. We assume private agents will use last year's final estimate (released in July) as a guide in forming their expectations for the first forecast. This seems reasonable, since a severe freeze during one year may continue to affect production the next year if trees were injured and, in general, current producing trees will have been planted several years earlier. The measure of future price changes leading to the October report is taken from the date of the July USDA crop production report.

The strong-form equation (5A) can also be used to approximate the market's current knowledge about the eventual realized orange production figure. Before the USDA crop forecast, the market's information includes $X_{m-1,t}$. After the forecast is announced, the market's information includes $X_{m-1,t}$ and $F_{m,t}$. The change in adjusted $R^2$ from before the announcement to after the announcement should be monotonically related to the new market information contained in the USDA forecast. To see this, let $\sigma_{m-1,t}$ and $\sigma_{m,t}$ represent the variances of the market forecast error before and after the release of a government crop forecast. Let $\sigma_t$ be the variance of the actual crop. The difference in $R^2$ between the successive regressions is

$$R^2_{m,t} - R^2_{m-1,t} = \frac{\sigma_{m-1,t} - \sigma_{m,t}}{\sigma_t}. \tag{6}$$

This difference is a measure of the relative value of monthly forecasts. It measures the reduction in the market's forecast error variance attributable to the USDA announcement. The smaller the difference, the better was the market's anticipation of the government's information, and the less valuable was that particular monthly report.

This issue is extremely important in assessing the role of the public sector in information dissemination. Roll's (1984) study concluded that public information explained little of the movement in FCOJ prices. For our purposes, this presumption is that the market has already absorbed the information contained in the USDA forecast so that the estimates of equation (6) should be small. We should also be able to determine when in the crop year the public information is most useful, if at all. Since the geographic production area is so small, private firms could easily collect their own data, reducing or eliminating the value of public information. Even the first USDA forecast may be of limited importance. Results from equation (6) will indicate the usefulness of USDA reports of oranges.

Weak-form tests of rationality are reported in Table I. Our findings indicate that USDA production forecasts for all four varieties of oranges are unbiased over the 51-year sample period. The joint $F$-test of the hypothesis

**Table I**

**Test of Unbiasedness of USDA Orange Forecasts, 1940 to 1992**

The Weak-Form $F$-Statistic comes from a test of the restriction that $\alpha_0 = 0$ and $\alpha_1 = 1$ in the regression equation:

$$Q_t = \alpha_0 + \alpha_1 F_{m,t} + \alpha_2 F_{m,t} * FDUM_t + \varepsilon_{m,t}$$

where $Q_t$ is the USDA final estimate, $F_{m,t}$ is the current USDA estimate and $FDUM_t = 1$ in freeze years and 0 otherwise. The coefficients and their standard errors are available from the authors by request.

| | Weak-Form $F$-Statistics | | | |
|---|---|---|---|---|
| | Florida | | California | |
| Month | Valencia | Early | Navel | Valencia |
| October | 0.066 | 0.905 | 0.567 | NA |
| December | 0.155 | 0.814 | 0.954 | 0.532 |
| January | 0.343 | 0.824 | 2.967* | 0.176 |
| February | 0.658 | 0.423 | 1.532 | 0.003 |
| March | 1.150 | 0.069 | 2.852* | 0.018 |
| April | 0.639 | 0.665 | 1.441 | 0.293 |
| May | 0.291 | 0.615 | 1.505 | 0.290 |
| June | 0.364 | 0.431 | 2.287 | 1.675 |

* Indicates significance at the 10 percent level.

that $\alpha_0 = 0$ and $\alpha_1 = 1$ in equation (5) is never rejected at the five percent level and only twice out of thirty-one times at the ten percent level.

Similar conclusions can be drawn from the results of strong-form tests of rationality reported in Table II. We perform these tests over the sample period 1973 to 1992, the years for which we were able to obtain futures price data. This period includes the years studied by Roll (1984). This test determines whether the government forecast error can be predicted by any variable in the market information set just prior to the release of the report. The null hypothesis that the government forecast is efficient and unbiased is rejected at the five percent level of confidence only for the January California Navel forecast. Four other estimations reject efficiency at the ten percent level. We conclude that USDA crop reports of orange production are unbiased and by and large do reflect all available public and market information.[9]

Table III reports the adjusted $R^2$ from direct estimation of equation (5A) for consecutive months excluding November.[10] The estimates are taken over the subsample beginning in 1973. The prereport $\tilde{R}^2$ for each variety is taken

[9] This analysis was also performed without the freeze variable. As expected, the USDA forecasts are then found to be biased and inefficient. This bias and inefficiency results from a model that incorrectly assumes that the USDA factors into its forecasts the expected loss from a potential freeze.

[10] The use of unadjusted $R^2$ yielded similar results. Because of the difference in the number of regressors for the prereport equations and subsequent equations in the crop year, comparisons of adjusted $R^2$ are appropriate.

**Table II**

**Test of Unbiasedness and Efficiency of USDA Orange Forecasts, 1973 to 1992**

The Strong-Form $F$-Statistic comes from a test of the restriction that $\alpha_0 = \alpha_3 = 0$ and $\alpha_1 = 1$ in the regression equation:

$$Q_t = \alpha_0 + \alpha_1 F_{m,t} + \alpha_2 F_{m,t} * FDUM_t + \alpha_3 X_{m-1,t} + \varepsilon_{m,t}$$

$Q_t$ is the USDA final estimate, $F_{m,t}$ is the current USDA estimate, $X_{m-1,t}$ is a vector of market information including past USDA government information and the futures price change since the last USDA report, and $FDUM_t = 1$ in freeze years and 0 otherwise. The estimated coefficients and their standard errors are available from the authors by request.

| | Strong-Form $F$-Statistics | | | |
|---|---|---|---|---|
| | Florida | | California | |
| Month | Valencia | Early | Navel | Valencia |
| October | 1.786 | 2.141 | 3.096* | 0.061 |
| December | 0.599 | 1.471 | 1.851 | 0.186 |
| January | 0.687 | 1.710 | 5.406** | 0.021 |
| February | 0.202 | 1.095 | 2.958* | 1.228 |
| March | 0.486 | 0.723 | 2.172 | 0.469 |
| April | 0.268 | 0.154 | 0.881 | 0.154 |
| May | 0.104 | 0.393 | 0.895 | 0.536 |
| June | 3.086* | 0.366 | 2.623* | 0.584 |

* Indicates significance at the 10 percent level.
** Indicates significance at the 5 percent level.

from a regression of final output on the previous year's output and the price change from the July report to the price just before the October report. Estimates for subsequent months represent the market's best guess of the final USDA estimate immediately after each month's report as modeled by equation (5A). As expected, there is close to a monotonic increase in $\tilde{R}^2$ across successive monthly reports for all varieties, indicating a monotonic reduction in the market's uncertainty about the harvest size. However, when we look at the pattern of information in Florida, it is clear that the role of public information is only important early in the crop year. Absent a freeze that cannot be known in October, there will be little new information after the first report. Later reports do contain some important additional news for the California varieties. Even so, almost two-thirds of the variation in the USDA July estimate is explained by the October forecast for both California varieties. Clearly, the first report is the most valuable for all varieties.

It seems clear from the $\tilde{R}^2$ of the prereport that the market leaves most of the serious production assessment up to the USDA. The price change since the July report and the previous year's final estimate in the prereport equation explain only a little over half of the variation in the final estimate of the Valencia varieties and less for Navel and Early. Clearly, the market does not presage very much of the USDA information even with the geographically

**Table III**

## Estimation of Changes in Market Information, 1973 to 1992

$\bar{R}^2$ is the corrected coefficient of determination for:

$$Q_t = \alpha_0 + \alpha_1 X_{m,t} + \alpha_2 F_{m,t}{}^* FDUM_t + \mu_{m,t}$$

$Q_t$ is the USDA final estimate. $FDUM_t = 1$ in freeze years and 0 otherwise. $X_{m,t}$ is the information set containing the price change since the last report, the previous USDA estimate, and (except for the prereport equation) the current month's USDA estimate.

| Variety | Month | Full Information $\bar{R}^2$ | Gain in $\bar{R}^2$ |
|---|---|---|---|
| Florida Valencia | Prereport | 0.558 | – |
| | October | 0.907 | 0.349 |
| | December | 0.892 | * |
| | January | 0.892 | * |
| | February | 0.937 | 0.030 |
| | March | 0.922 | * |
| | April | 0.924 | * |
| | May | 0.929 | * |
| | June | 0.980 | 0.043 |
| Florida Early | Prereport | 0.392 | – |
| | October | 0.931 | 0.539 |
| | December | 0.926 | * |
| | January | 0.941 | 0.010 |
| | February | 0.954 | 0.013 |
| | March | 0.984 | 0.030 |
| | April | 0.999 | 0.015 |
| | May | 0.999 | 0.000 |
| | June | 0.999 | 0.000 |
| California Navel | Prereport | 0.302 | – |
| | October | 0.669 | 0.367 |
| | December | 0.828 | 0.159 |
| | January | 0.932 | 0.104 |
| | February | 0.956 | 0.024 |
| | March | 0.970 | 0.014 |
| | April | 0.962 | * |
| | May | 0.963 | * |
| | June | 0.988 | 0.018 |
| California Valencia | Prereport | 0.542 | – |
| | October | 0.648 | 0.106 |
| | December | 0.644 | * |
| | January | 0.712 | 0.064 |
| | February | 0.716 | 0.004 |
| | March | 0.697 | * |
| | April | 0.723 | 0.007 |
| | May | 0.768 | 0.045 |
| | June | 0.885 | 0.117 |

* Indicates no apparent gain in market information.

small areas to be sampled. The role of public data gathering is still very important.

Further evidence supporting the importance of USDA forecasts comes from the number of times the USDA forecasts were associated with limit moves the next day in FCOJ futures. Over the nineteen years studied, limit moves occurred after announcements thirteen times in October, four times in February, three times in April, twice each in January and March, and none in November, December, May, or June. In each case, news stories attributed the price movement to the report. Of the thirteen October limit moves, three were for more than one day following. Barring a freeze, there were few surprises after the first estimate. Eight of the eleven limit moves associated with months other than October occurred in freeze years, and press reports attributed all of these moves to surprises in USDA estimates of freeze damage.

## IV. Price Response to USDA Forecasts

Having concluded there is valuable information in government reports of oranges, the next step is to uncover its effect on price. As a beginning strategy, we assume the market tries to anticipate the USDA forecasts, given the reports' conditional unbiasedness and efficiency. If the market for frozen concentrate is also efficient, price will respond only to unanticipated information. By taking account of market expectations, a pure price response to new information can be more clearly observed, and the importance of USDA production estimates to the market can be determined. Roll (1984), in essence, included both anticipated and unanticipated information in his analysis and constrained both coefficients to be the same. This article's goal is to disentangle the two and observe the separate price effects if any.

We use the following two-step model:[11]

$$F_{m,t} = F^*_{m,t} + \mu_{m,t} = Y_{m-1,t}\beta + \mu_{m,t} \tag{7}$$

$$\Delta P_{m,t} = \gamma_0 + \gamma_1(F_{m,t} - F^*_{m,t}) + \gamma_2 F^*_{m,t} + \eta_{m,t} \tag{8}$$

$F^*_{m,t}$ is the true market expectation of $F_{m,t}$ and is related to a $(1 \times k)$ vector of predetermined variables, $Y_{m-1,t}$. $\Delta P_{m,t}$ is the change in levels in FCOJ futures prices from the closing price on the day of the USDA report to the closing price on the day following the report.[12] A proxy for $F^*$ is the fitted value from the regression of $F_{m,t}$ on $Y_{m-1,t}$. Substituting into equations (7) and (8), the two-step model becomes

$$F_{m,t} = \hat{F}_{m,t} + \hat{\mu}_{m,t} = Y_{m-1,t}\hat{\beta} + \hat{\mu}_{m,t}. \tag{7A}$$

$$\Delta P_{m,t} = \gamma_0 + \gamma_1 \hat{\mu}_{m,t} + \gamma_2 \hat{F}_{m,t} + \tilde{\eta}_{m,t} \tag{8A}$$

[11] Pagan (1984) shows that the coefficient vector $\gamma$ in equation (8A) will be unbiased. Pagan's corrected covariance matrix for equation (8A) was used to compute the standard errors in Tables IV and V.

[12] The previous remarks about limit moves still apply here. If the close on the day following the report is a limit move, the closing price is taken to be the close on the first nonlimit day.

where the regression residual $\hat{\mu}_{m,t}$, is the unanticipated supply and $\hat{F}_{m,t}$ is the anticipated supply. $Y_{m-1,t}$ primarily contains three relevant pieces of information known to agents before the 2 P.M. USDA announcement: the previous USDA forecast, $F_{m-1,t}$, the change in price between reports, $\Delta P_{m-1,t}$, and knowledge of freezes since the last USDA report, represented by $DUM_{m,t}$. $DUM_{m,t} = 1$ if $t$ is a year such that a freeze occurred during the previous calendar month; it is zero otherwise.

The price response regressions were obtained by stacking all monthly observations for each variety. Table III shows that some monthly reports produce little news; stacking the data aggregates the information contained in individual months so the price response can be more clearly discerned. Stacking in this manner constrains the coefficients to be equal across all months. This seems reasonable for the demand equation (8A). For the first-step equation predicting the government forecast, however, this assumption is too restrictive. It is necessary to allow different coefficients for the month of October because of the differences in the specification of the market's information set.[13] This was accomplished by interacting all the regressors in equation (7A) with a dummy variable, which took the value of one in the month of October and zero otherwise.

Estimates of $\gamma_1$ and $\gamma_2$ in equation (8A) measure respectively the effect on the price of unanticipated and anticipated supply. If this market is efficient, we will not reject the hypothesis that estimated coefficients $\gamma_0$ and $\gamma_2$ are jointly zero. Further, if the forecast contains news useful to the market, then $\gamma_1$ will be significantly negative. Finally, since most concentrate is processed from Florida oranges and very little from California oranges, a significant $\gamma_1$ for either California variety would indicate the existence of cross-crop effects. Since the markets are integrated and the products are similar, substitution effects are expected.

Table IV reports the results from estimating equation (8A). The results for Florida and California Valencia varieties differ qualitatively from those of Florida Early and California Navel. Unanticipated supply changes of both Valencia varieties significantly affect FCOJ futures prices, while estimated coefficients of expected supply changes for all varieties are not significant. Tests of the null hypothesis that the constant and anticipated coefficients are jointly zero fail to be rejected at the ten percent level of confidence. For Early and Navel varieties, none of the estimated coefficients are significant, and the hypothesis that all the coefficients are jointly zero cannot be rejected at standard confidence levels. Apparently, FCOJ futures prices do not respond to supply changes of Early or Navel oranges. All the information in the USDA forecasts of Early and Navel must either be anticipated by market agents or have little value to them. We conclude from these results that the frozen

[13] First, $F_{m-1,t}$ for October is last year's final estimate rather than the current year's previous USDA estimate as it is for all other months. Second, the price change, $\Delta P_{m-1,t}$, takes place over three months rather than one. The influence of this diverse information, and thus the estimated coefficients, would be expected to be quite different and needs to be recognized in the stacked regressions.

**Table IV**

**Response of FCOJ Futures Price to Information Contained in USDA Orange Production Announcements, 1973 to 1992**

Price response ($\Delta P_{m,t}$) to the unanticipated ($\hat{\mu}_{m,t}$) and the anticipated ($\hat{F}_{m,t}$) components of USDA forecasts is measured by least squares, using the following regression equations for Panels A and B, respectively:

Panel A:

$$\Delta P_{m,t} = \gamma_0 + \gamma_1 \hat{\mu}_{m,t} + \gamma_2 \hat{F}_{m,t} + \tilde{\eta}_{m,t}$$

Panel B:

$$\Delta P_{m,t} = \gamma_0 + \gamma_{1F} \hat{\mu}_{F,m,t} + \gamma_{1,C} \hat{\mu}_{C,m,t} + \gamma_{2,F} \hat{F}_{F,m,t} + \gamma_{2,C} \hat{F}_{C,m,t} + \tilde{\eta}_{m,t}$$

The $F$ and $C$ subscripts in the equation for Panel B refer to Florida and California Valencia respectively. Standard errors are corrected for possible heteroskedacity using the method proposed by Pagan (1984).

Panel A: Single Crop Effects

| | $\gamma_0$ | $\gamma_1$ | $\gamma_2$ | $R^2$ |
|---|---|---|---|---|
| Florida Valencia | −3.93 | −9.13** | −0.010 | 0.28 |
| | (214.3) | (1.14) | (0.317) | |
| Florida Early | 108.57 | −0.545 | −0.138 | 0.005 |
| | (202.9) | (0.832) | (0.232) | |
| California Navel | 87.78 | −1.347 | −0.333 | 0.005 |
| | (173.4) | (1.842) | (0.575) | |
| California Valencia | −195.57 | −12.79** | 0.784 | 0.11 |
| | (218.0) | (2.89) | (0.915) | |

Panel B. Multiple Crop Effects

| | $\gamma_0$ | $\gamma_{1F}$ | $\gamma_{1C}$ | $\gamma_{2F}$ | $\gamma_{2C}$ | $R^2$ |
|---|---|---|---|---|---|---|
| California and Florida Valencias | −327.8 | −8.95** | −10.87** | 0.049 | 1.22 | 0.37 |
| | (254.4) | (1.11) | (2.45) | (0.304) | (0.782) | |

* Indicates significance at the 10 percent level.
** Indicates significance at the 5 percent level.

concentrate market is efficient with respect to news contained in USDA reports, i.e., that FCOJ futures prices do respond significantly to some unanticipated changes in the supply of oranges, and that prices do not react to changes that are anticipated.

Results also show definite cross-crop effects. Futures prices of frozen concentrate have been thought to be largely unaffected by supplies of California oranges. In fact, we find strong negative impacts of unanticipated California Valencia supply on FCOJ futures prices, which indicates substitution potential of California for Florida Valencia oranges. It is possible that they are not substitutes in the production of frozen concentrate, but these results confirm that they are at least substitutes in consumption. We tested the robustness of these cross-crop effects by including supply changes of both

Valencia varieties in the same regression (Panel B of Table IV). The coefficients decrease slightly in magnitude but retain significance.[14]

As in Roll (1988), the $R^2$ in Table IV measures the degree to which price movements can be explained ex post by public supply announcements. At best, in Panel B of Table IV, we can explain only thirty-seven percent of the price variance by changes in supply. In other words, despite providing quite accurate and useful information on supply, the USDA can account for little more than one-third of the variance in price on the days when this public information is expected to be must beneficial.

Separate analysis of data from individual months confirms the conclusion from Table III that most useful information in the USDA reports is contained in the October announcement. Price change equations estimated for subsequent months generated few significant individual coefficients, and unanticipated government announcements had little power to explain price variation. The results for October, as shown in Table V, are quite different.[15] October USDA reports explain almost two-thirds of the price variation on the announcement date. Only the later announcements, which our results from Table III suggest were less informative, fail to explain the majority of price movements on announcement days.

The lack of significant effects of Florida Early or California Navel oranges on FCOJ prices merits further comment. It is likely that government production information is irrelevant for Florida Early oranges, some of which mature in October. Most of the production information may be old news to the market by the time the government releases the October report. The results in Table II indicate that little new information on Earlys is contained in subsequent reports. Even the October report failed to generate a significant negative price response when we estimated equation (9) using just October USDA forecasts in the sample.

California Navels are not particularly suitable for processing into frozen concentrate.[16] They are almost all consumed fresh. Nonetheless, if fresh oranges are substitutes for orange juice, Navels should still have an effect on FCOJ prices. Although the coefficient on unanticipated Navel supply is negative, the coefficient is smaller than its standard error. Presumably fresh and processed oranges are not considered close substitutes by consumers, so no significant FCOJ price response results from unanticipated Navel supply.

## V. Conclusion

Our findings show that USDA forecasts of the production of oranges are unbiased and efficient. While market participants form relatively accurate

[14] The joint test that the coefficients for Florida and California unanticipated Valencia supply are identical could not be rejected at the ten percent level of significance. This similarity in price response is consistent with the fact that some California Valencia oranges are processed every year, and more are used for processing when freezes damage the Florida crop.

[15] The rest of the monthly information is available from the authors by request.

[16] See Wardowski, Nagy, and Grierson (1986).

**Table V**

**The Response of FCOJ Futures Price to Information Contained in October USDA Orange Production Announcements, 1973 to 1992**

Price response ($\Delta P_{m,t}$) to the unanticipated ($\hat{\mu}_{m,t}$) and the anticipated ($\hat{F}_{m,t}$) components of USDA forecasts is measured by least squares, using the following regression equations for Panels A and B, respectively:

Panel A:

$$\Delta P_{m,t} = \gamma_0 + \gamma_1 \hat{\mu}_{m,t} + \gamma_2 \hat{F}_{m,t} + \tilde{\eta}_{m,t}$$

Panel B:

$$\Delta P_{m,t} = \gamma_0 + \gamma_{1F} \hat{\mu}_{F,m,t} + \gamma_{1,C} \hat{\mu}_{C,m,t} + \gamma_{2,F} \hat{F}_{F,m,t} + \gamma_{2,C} \hat{F}_{C,m,t} + \tilde{\eta}_{m,t}$$

The $F$ and $C$ subscripts in the equation for Panel B refer to Florida and California Valencia respectively. Standard errors are corrected for possible heteroskedacity using the method proposed by Pagan (1984).

Panel A. Single Crop Effects

| | $\gamma_0$ | $\gamma_1$ | $\gamma_2$ | $R^2$ |
|---|---|---|---|---|
| Florida Valencia | −1527 | −12.12** | 2.20 | 0.44 |
| | (3232) | (3.5) | (4.5) | |
| Florida Early | 1423 | −0.444 | −1.58 | 0.02 |
| | (7966) | (2.6) | (2.8) | |
| California Navel | 5106 | −1.41 | −17.17* | 0.23 |
| | (2917) | (5.27) | (9.8) | |
| California Valencia | −5614 | −22.66** | 23.46 | 0.29 |
| | (8287) | (10.1) | (34.6) | |

Panel B. Multiple Crop Effects

| | $\gamma_0$ | $\gamma_{1F}$ | $\gamma_{1C}$ | $\gamma_{2F}$ | $\gamma_{2C}$ | $R^2$ |
|---|---|---|---|---|---|---|
| California and Florida Valencias | −7459 | −11.48** | −19.15** | 3.35 | 21.60 | 0.66 |
| | (5034.6) | (3.09) | (7.48) | (4.13) | (27.4) | |

* Indicates significance at the 10 percent level.
** Indicates significance at the 5 percent level.

expectations of USDA estimates, the market does not fully anticipate the public information. The empirical work demonstrates that FCOJ prices respond to public information on orange supply in a manner consistent with economic theory. Nevertheless, our results still corroborate Roll's (1984) conclusion that public information cannot account for a majority of the price variation. Little more than one-third of the announcement-day variation in FCOJ prices can be explained by USDA announcements of orange production.

On the other hand, USDA forecasts add little information to the market after the initial October forecast. Consistent with that finding, the October USDA orange crop forecast explains two-thirds of the price movements on the day of that announcement. Adding successive months of progressively less informative USDA forecasts to the data set dilutes the apparent measured importance of public information. What remains unexplained is the cause of price movements on these later announcement dates.

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