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by

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Giannini Foundation for Agricultural Economics**

Do Quality Incentives Matter?

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Do Quality Incentives Matter?

ABSTRACT: We utilize an unusual data set, involving fifteen tomato growers over four years, to analyze the impact of incentive contracts on behavior. Each grower delivers processing tomatoes under a price incentives contract and for a fixed price per ton. Our comparison of the quality of the tomatoes delivered under the two arrangements confirms that growers do respond to incentive contracts by improving tomato quality, as predicted by economic theory. The comparison is not confounded by the usual contract endogeneity and simultaneity problems, due to characteristics of the processing tomato industry and our data set.

1. INTRODUCTION

People respond to financial incentives in contracts, or so economists believe. While such a response is obvious theoretically, it is difficult to obtain conclusive support empirically. Observed data are often subject to tremendous simultaneity problems regarding contract determination and performance under the contract. Because agents' contract choice is endogenous, relative to incentives in the contracts, any data solely on performance under a contract are incomplete. In most cases, agents select only one contract, so that it is impossible from any such data themselves to eliminate the possibility that a hidden factor influences both contract choice and ensuing performance. Furthermore, contract provisions and agent performance under contracts are often proprietary information, so obtaining data is difficult.

Our data set allows us to avoid these problems, and to draw correspondingly stronger conclusions from our results. First, the structure of the processing tomato industry insulates our data from common incentive endogeneity problems. If there was a continuous contracting situation, we would expect to see the continuous evolution of contract terms and a large variety of contracts. In contrast, our contracts are identical for everyone contracting *in a given year*. Similarly, the bargaining convention for the industry (discussed in section two) guarantees that the processor must offer a contract to the growers each year on a take it or leave it basis, so that the simultaneity problem is subdued. We can isolate what growers do in response to the contract incentives, due to the sequencing and bargaining choices in the industry.

Second, since the analyzed growers all deliver tomatoes under the incentive contract and for a fixed price, we avoid selection problems based on contract choice. For each grower, we have information on tomato quality for tomatoes delivered under a quality incentive contract, and for tomatoes delivered for a fixed price. Our sample represents the complete population of all tomatoes delivered to a processor by a group of growers over a four year period. In this respect, and in its avoidance of simultaneity and endogeneity problems, it resembles the data set used by Lemmon,

Schallheim and Zender (2000) to analyze fund manager compensation, which has perhaps the fewest data-based analytical problems among existing studies.

Our data set has several other methodological advantages. First, unlike the Lemmon et al. sample of seven relatively homogeneous principals, our sample has a single principal. This provides perfect control for unobservable differences across principals that may affect agent behavior under a contract. Second, the sample size is quite large: 33,001 observations on loads of tomatoes delivered by fifteen growers over four years, in 766 grower/variety/year/week categories. Third, the sample is multi-dimensional: there are a number of tomato attributes that processors value, some of which are less costly than others for growers to deliver. Hence, we have a number of measurable responses to an incentive payment production cost choice, rather than a single response. These attributes and the grower decisions that influence them are discussed in section three. Fourth, all quality attributes are graded by an independent third-party, the state of California, so that neither party to a contract can deliberately misstate or mismeasure quality.

Existing empirical studies primarily address other examples of incentive contracts, such as managerial compensation (e.g., Lemmon et al. (2000) and Murphy (1986)), and franchising (e.g., LaFontaine (1992) and LaFontaine and Shaw (1999)). In part, this emphasis is due to the difficulties of obtaining data on contract terms and outcomes. In the case of managerial compensation, the reporting requirements for publicly-held companies provide a data source. Similarly, franchising studies compile information from a number of published sources. The few existing studies that address the effect of financial incentives on real behavior under agricultural contracts use originally proprietary data based only on outcomes under a contract. They do not observe outcomes in the absence of the contract, so that their conclusions are subject to concerns regarding sample selection (Knoeber and Thurman 1994, Goodhue, Rausser and Simon 1998). Hence, our study is distinguished from them for the same methodological reasons as above.

2. PROCESSING TOMATO MARKET

Most processing tomatoes are made quickly into paste during the harvest season.¹ The paste is stored for further processing (ketchup, tomato sauce, etc.) throughout the year. Before tomatoes are accepted for delivery at the processing plant, they undergo a state-mandated grading process at a state inspection station. The state inspection stations grade all of the tomatoes based on seven categories: percentage of tomatoes with worm damage, the Agtron color score, percentage of tomatoes with mold damage (mold), percentage of green tomatoes (Greens), percentage of material other than tomatoes (MOT), percentage of limited use tomatoes (LU), and the sugar content or net soluble solids (NTSS).² Loads with excessive mold, Greens, limited use tomatoes, worms and material other than tomatoes are subject to weight deductions; that is, a ton of harvested tomatoes may be only 1800 pounds of delivered (price-eligible) tomatoes, if the quality is too low. Below specified quality thresholds, the processor may reject the load.³

Over two-thirds of the state's tomato growers belong to the California Tomato Growers' Association (CTGA), which acts as a collective bargaining agent⁴. The CTGA negotiates contracts with each processor individually on behalf of the growers contracting with that processor. The negotiations determine a base price and any quality incentive payments. Many processors use incentive payments, for example, Campbell Soup Co., Morning Star Packing Co. and Stanislaus Food Products all negotiated quality payments for the 1999 season. The relative and absolute magnitudes differ across processors. Another interesting feature of these contracts is that tomatoes delivered in the last weeks of the season often receive a per ton late season premium above the base price, regardless of graded quality.

Once the CTGA approves a contract, the processor is free to offer it to growers on a take it or leave it basis. The negotiated contract is effectively a minimum price contract; although the negotiated contract is not technically binding for producers who are not CTGA members, the processors are prohibited from offering a lower priced contract to non-members. (Anecdotally, processors do not

choose to offer higher-priced contracts, although this would be permitted.) While the ex ante bargaining process may limit the appropriateness of contract theory for evaluating *contract design*, it does not distort the usefulness of examining *contract outcomes* to see if individual growers respond to contract provisions.

Most processing tomatoes are delivered under contract. Industry observers estimate that roughly ninety-eight percent of processed tomatoes are contracted, which is consistent with the division in our sample. The remaining two percent, however, are essential for the smooth functioning of the tomato marketing system. Once a processing plant begins operating for the season, it must maintain the flow of tomatoes. If an inadequate supply forces the plant to shut down, it is very costly to reopen, since the entire system must be reesterilized. Processors purchase no-contract tomatoes in order to ensure a smooth flow of inputs. These no-contract tomatoes are purchased by processors according to posted prices. While processors determine these prices, the market does not function as a true spot market, since posted prices remain constant for a number of weeks and do not reflect the marginal value of the tomatoes to the processor.

3. MODEL

Our theoretical model is presented in the appendix. Here, we summarize the logic of our model and present our testable hypotheses. Growers deliver tomatoes under the contract with the associated quality premiums, and deliver tomatoes for a flat price with no quality *price* adjustments. (These fixed price deliveries are subject to the same schedule of quality-based weight deductions as tomatoes delivered under contract.) Clearly, eliminating the price incentives for increased quality reduces the marginal benefits to a grower of increasing tomato quality and leaves the cost function unaffected. Consequently, we would expect tomatoes delivered for a fixed price to be of lower quality than tomatoes delivered under a contract with price incentives for quality.⁵ The effects on output are less clear, since eliminating the price incentives affects both its marginal benefit and marginal cost. We obtain the following two testable hypotheses regarding tomato quality:

Hypothesis One: *Tomatoes delivered for a flat price per ton are lower quality than are tomatoes delivered under a quality incentive contract.*

Hypothesis Two: *Under the quality incentive contract, tomatoes that receive a late season premium are lower quality than other contract tomatoes are.*

We develop an empirical model of quality production in processing tomatoes in order to determine whether growers respond to price incentives for quality as predicted by economic theory. Figure One summarizes major producer decisions and other factors, such as weather, and their effects on tomato quality. In order to respond to quality incentives, growers must be able to affect tomato quality. Growers' harvest timing and sorting decisions are the primary ways in which they can affect tomato quality attributes, with the exception of NTSS (net soluble solids).

A highly skilled grower will time the harvest to maximize the share of ripe tomatoes and minimize the share of LU (limited use) tomatoes: the conventional rule of thumb is to harvest when 95% of the tomatoes are ripe. Harvesting too early can reduce NTSS and increase reens. As the tomatoes ripen, controlling the share of LU tomatoes becomes a bigger concern. A grower may also choose to apply ethephon to speed ripening, even though this may reduce his harvest window for optimal quality. Ethephon is most commonly used early in the season and late in the season when cooler temperatures slow ripening. The harvest window for very high quality tomatoes varies greatly across tomato varieties. It can be as long as two or three days, but using ethephon narrows this harvest window. The harvest window for acceptable quality is much longer, and even lasts ten days for some varieties. The processor's scheduling needs influence the time of harvest, but the decision rests primarily with the grower.

The grower's sorting decisions during harvest affect the share of LU, Mold, Greens and MOT (material other than tomatoes). If the grower mistimes the harvest, i.e. harvests too late when there is a large share of LU, or too early when there is a large share of Greens, the grower can still deliver high quality by increasing sorting effort. First, the grower sets the sensitivity level

of the mechanical sorter which is particularly effective at removing green tomatoes and MOT. However, it is possible for the mechanical sorter to be too sensitive, so that it will reject too many good tomatoes. Second, the grower chooses how many workers ride the harvester and remove LU, Mold, Greens and MOT. More workers increases sorting effectiveness but also increases labor costs. Finally, the farmer chooses the speed of the tomato harvester. The workers can sort more effectively when the harvester is moving slowly, but again labor costs increase.

Profit-maximizing growers equalize the price per delivered ton with the marginal cost of producing tomatoes with the requisite quality. Different tomato quality attributes are affected by different production decisions, and the attributes vary in their costliness of production. The grower's decision is described by a set of five equations, one for each quality variable. These equations are in reduced form. We do not explicitly model cross-effects among the variables, although such effects certainly exist.

NTSS is determined by the tomato variety, weather, time of season and grower practices. Sugar content varies greatly across tomato varieties so we include tomato variety dummy variables to control for these effects. The sugar content of tomatoes tends to increase over the course of the season and is affected by average daily temperatures. We include week-year dummies to control for these effects. The contract late season variable may capture weather effects, however, it will also capture the effect of the late season premium, which will tend to decrease NTSS, so that the net effect is indeterminate. Since the growers in our sample are located throughout inland central California, from the southern end of the San Joaquin Valley to the southern quarter of the Sacramento Valley, we include grower dummy variables and grower-variety interaction variables to account for soil and microclimate effects. The grower dummy will also reflect any differences in grower management ability that affect tomato quality. In the full sample regressions we include dummy variables for the year to control for large scale weather differences such as a cool spring

that delays the start of the processing season. The year dummy variables will also capture the small changes in the marginal contract incentives across years.

Increasing NTSS comes at the expense of yield, making NTSS the most expensive quality to deliver.⁶ If the contract incentives are sufficiently large we expect that grower effort will increase NTSS. Thus, we expect a negative coefficient on the dummy variable for no-contract. Accordingly, we specify the following equation:

$$\mathbf{NTSS} = \beta_1 + \underbrace{\beta_{\text{NC}}}_{-} \text{NC} + \underbrace{\beta_{\text{LATE}}}_{\text{indet.}} \text{LATE} + \beta_V V_i + \beta_{\text{WY}} \text{WY}_j + \beta_g g_k + \beta_{gV} gV_{k,i} + \epsilon_{\text{NTSS}} \quad (1)$$

where β_1 is the intercept, NC is the dummy variable for no-contract, LATE is the dummy variable for a contract load eligible for the late season premium, V_i denotes the variety dummy variable for the i th variety, WY_j denotes the dummy variable for the j th week-year period, g_k denotes the dummy variable for the k th grower, and $gV_{k,i}$ denotes the dummy variable for the interaction between the k th grower and the i th variety. ϵ_{NTSS} is the error term for the equation. Predicted signs are indicated below the coefficients, where appropriate.

The share of limited use (LU) tomatoes depends on grower skill and weather. Hotter weather at harvest-time tends to increase the share of limited use tomatoes. We include week-year dummy variables to account for these weather effects. We include grower, variety and grower-variety dummy variables for the same reasons as above: microclimate, soil, innate ability, and variety differences. The grower can choose to harvest at night when the weather is hot in order to decrease the share of LU tomatoes. Accordingly, we make the following predictions: We expect to see the share of LU tomatoes to decrease when the grower harvests at night and when the grower is rewarded for reduced LU with contract incentives. Thus, we predict a negative coefficient on the night harvest variable and a positive coefficient on the no-contract variable. The late season premium will reduce the grower's incentive to improve quality, so we would expect a positive coefficient on the contract

late season variable. Thus, the estimated equation for (9) is

$$\mathbf{LU} = \beta_2 + \underbrace{\beta_{\text{NC}}}_{+} \text{NC} + \underbrace{\beta_{\text{LATE}}}_{+} \text{LATE} + \underbrace{\beta_{\text{NIGHT}}}_{-} \text{NIGHT} + \beta_V V_i + \beta_{WY} WY_j + \beta_g g_k + \beta_{gV} gV_{k,i} + \epsilon_{\text{LU}} \quad (2)$$

where β_2 is the intercept, NIGHT is the dummy variable for harvesting at night, and the other dummy variables are as previously described. ϵ_{LU} is the error term for the equation.

Mold damage occurs after heavy rains. We include week-year dummies to account for these weather effects. Commonly, only fields harvested in late September and October face the possibility of a heavy rain. As in the previous equations, we include grower, and grower-variety dummy variables.

The grower can influence the percentage of mold through his harvest decisions. The grower may be able to harvest early, before the mold damage is severe but harvesting early generally implies a higher percentage of green tomatoes and a lower sugar content, which both reduce payments. As with LU tomatoes, the mechanical sorter is not very effective at removing moldy tomatoes, so that it can be very costly to deliver a load of tomatoes with little mold damage. We expect the coefficient on the contract late season variable to be positive due to both weather reasons and incentive reasons, since the late season premium reduces the incentive to improve quality. We predict that the coefficient on the no-contract variable will be positive, for similar reasons as those discussed above. We specify the following equation, where β_3 is the intercept and ϵ_{Mold} is the error term:

$$\mathbf{Mold} = \beta_3 + \underbrace{\beta_{\text{NC}}}_{+} \text{NC} + \underbrace{\beta_{\text{LATE}}}_{+} \text{LATE} + \beta_{WY} WY_j + \beta_g g_k + \beta_{gV} gV_{k,i} + \epsilon_{\text{Mold}} \quad (3)$$

The cheapest tomato qualities to deliver are the percentage of Greens and MOT. The mechanical sorter is very effective at removing green tomatoes and MOT. We expect to see Greens and MOT decrease with the grower's sorting effort, when the grower is rewarded by contract incentives. As a result, positive coefficients on the no-contract and contract late season variables are expected. Thus the following equation, where β_5 is the intercept and $\epsilon_{\mathbf{MOT}}$ is the error term, specifies (11) appropriately:

$$\mathbf{MOT} = \beta_5 + \underbrace{\beta_{\mathbf{NC}}}_{+} \mathbf{NC} + \underbrace{\beta_{\mathbf{LATE}}}_{+} \mathbf{LATE} + \beta_g g_k + \epsilon_{\mathbf{MOT}} \quad (4)$$

In addition to grower sorting effort, the percentage of Greens can also be affected by the tomato variety and weather effects. The following equation, where β_4 is the intercept and $\epsilon_{\mathbf{Greens}}$ is the error term explains the percentage of Greens:

$$\mathbf{Greens} = \beta_4 + \underbrace{\beta_{\mathbf{NC}}}_{+} \mathbf{NC} + \underbrace{\beta_{\mathbf{LATE}}}_{+} \mathbf{LATE} + \beta_V V_i + \beta_{WY} WY_j + \beta_g g_k + \beta_{gV} gV_{k,i} + \epsilon_{\mathbf{Greens}} \quad (5)$$

4. DATA

Our data set contains quality information on all the tomatoes delivered to one processing plant by a set of growers. All of the growers in the data set delivered tomatoes both under an incentive contract with price rewards and punishments for quality incentives, and for a fixed price. Tomatoes delivered under both types of contracts were subject to quantity adjustments for quality problems, according to the standard schedule used in the industry. Tomatoes delivered in contractually-indicated, year-specific weeks *under the incentive contract* received a late season bonus worth 10-30% of the base price per quality-adjusted ton. The data covers four years of tomato deliveries, from 1994-1997, on a load basis, for a total of 33,001 loads in 766 distinct grower-variety-year-week categories. For each load of tomatoes, the data set contains information on the seven state-graded quality attributes, the date and time of harvest, the tomato variety, a grower identification number,

and whether the load was delivered under an incentive contract or for a fixed price. No loads were rejected based on quality in the sample.

For confidentiality reasons, we do not report specific values of marginal quality incentives or base prices in specific years. Overall, the price incentives account for roughly 5% of the price per ton for a representative ton of tomatoes. While this may not seem to be a significant percentage, this margin is important, given costs and returns in the processing tomato industry. In 1997, for example, a producer with the state average yield per acre who incurred the costs estimated in the 1997 UC Extension Yolo County processing tomato budget and who received the base price from our data sample would have essentially zero profits. Thus, his performance on the quality incentives would determine whether he made a profit or a loss.⁷

Data are available on seven quality attributes graded by the state inspection stations: percentage of tomatoes with mold damage (mold), percentage of green tomatoes (Greens), percentage of material other than tomatoes (MOT), percentage of limited use tomatoes (LU), and the sugar content or net soluble solids (NTSS). We do not analyze the worm damage category because less than one percent of the loads contained worm damage. We do not analyze the color score because the incentive contracts do not specify marginal incentives related to color and there are no weight adjustments for color. Furthermore, industry sources say that tomato loads are never rejected due to color since the processor can mix tomato loads to achieve a good color. If the paste still turns out to have poor color, the processor can blend it with other paste to achieve an acceptable color.

5. RESULTS

We tested our empirical model using the entire data set, 1994-1997, and using 1996 data only, when 38% of the no-contract tomatoes were delivered. Testing a subsample for a single year allows us to control for small changes across years in the relative magnitude of the contract payments for the different quality attributes. It provides a more consistent set of biological factors and weather conditions. Applying ordinary least squares by equation results in a failed White's test for

heteroskedasticity for both the full sample and subsample, so we report least squares regressions by equation with White's corrected standard errors. The processing tomato production process suggests that quality errors may be correlated across attributes. We ran a seemingly unrelated regression, to correct for any such effects. Under both specifications for the full sample and the 1996 subsample, the results were consistent for ordinary least squares using White's correction for heteroskedasticity and using seemingly unrelated regressions. Quantitatively, results for a sample were not substantially affected by the model specification. Qualitatively, results were similar across samples. This consistency was likely due to the large sample sizes. Overall, the results indicate that growers do respond to quality incentives. No contract tomatoes are of lower quality than contract tomatoes. Results from the 1996 subsample support the hypothesis slightly more strongly than do results from the entire sample.

NTSS: For the equation with NTSS as the dependent variable, the coefficient on NC was positive and significant for the full four-year sample. This not only contradicts our null hypothesis but it is counterintuitive because it implies that growers deliver higher quality without incentives. Recall, however, that in our development of our empirical model the predicted sign on LATE was indeterminate, due to the opposing influence of biological factors. This result suggests that biological factors dominate contractual incentives: NTSS increases later in the season. While not all no-contract tomatoes were in the official late season window, they were mostly delivered in the latter two-thirds of the harvest season. This explanation is further supported by the positive and significant coefficient for contract late season tomatoes.

In the 1996 only regression, in contrast, the coefficient on the no contract loads was negative and significant. In this year, contractual incentives dominated biological factors. This finding makes sense intuitively, since biological considerations are more consistent across tomato loads within a given year, while contractual incentives still vary. The dummy on the contract, late season loads

was negative and significant which implies that the late season premium reduced the quality of the tomatoes, as predicted.

LU: The coefficient on the no-contract dummy was positive and significant for all samples and specifications; no-contract loads statistically have a larger share of LU tomatoes. For LU, we reject the null hypothesis that growers do not respond to contract incentives. The coefficient on the contract, late season dummy was positive in all the regressions, but was significant only in the 1996 only regressions. The sign is consistent with the hypothesis that the late season premium reduces the impact of other contract incentives on the grower behavior. The coefficient on the dummy variable for harvesting at night was negative and significant which is consistent with the expectation that LU decreases with cooler temperature.

Mold: With mold as the dependent variable, the coefficient on NC was positive and significant for all four regressions. For mold, we reject the null that growers do not respond to the contract incentives. The coefficient for the contract, late season tomatoes was positive, large and significant, which is consistent with both incentive and weather explanations.

MOT: For the equation with MOT as the dependent variable, the coefficient on NC was positive and significant. Hence for MOT we reject the null hypothesis in favor of the alternative that growers do indeed respond to the contract incentives. The contract, late season dummy also had a positive, significant coefficient which is consistent with our hypothesis that the late season premium may reduce the impact of the contract incentives on the grower's decisions.

For the 1996 data, the coefficient on NC is still positive as expected although it is significant at the 1% level only in the SUR regression and is not significant in the corrected OLS regression. The coefficient on LATE is negative and significant in both regressions, although it is significant at the 1% level only in the SUR regression. The sign on the LATE coefficient is the opposite of the sign for the sample as a whole, and contradicts our hypothesis that the late season premium will be associated with higher levels of MOT.

Greens: For the 1996 data, the coefficients on the no-contract dummy and the contract, late season dummy are positive, as predicted, and significant. For the full sample regressions with Greens as the dependent variable, the coefficients on NC and late were positive but insignificant. In part, this may be due to the nature of the price incentives for this variable, which are second-order relative to the price incentives for the other quality attributes.

6. CONCLUSION

We have utilized data on tomatoes delivered under a price incentive contract and a fixed price to examine if growers respond to quality incentives. The data set allowed us to control for common problems related to testing the real effects of incentives. The delivery of both contract and no-contract tomatoes provided us with a robust test of the effects of incentives on growers' quality provision decisions. If we did not have no-contract tomatoes, then we would not have been able to test for quality differences based on the presence or absence of incentives. Instead, we would have had to rely on responses to small changes in marginal incentives, which are more difficult to detect econometrically. For example, we most likely would have been unable to test marginal responses in a reduced-form model, since interactions among quality variables would become much more significant in explaining grower responses.⁸ This suggests that conclusions drawn on the basis of small marginal changes in incentives are much more sensitive to model specifications.

The use of deliveries only by growers that deliver both contract and no-contract tomatoes allowed us to control for any grower-specific effects that influence both contract choice and delivered quality. The data set was drawn from a larger data set (147,000 load observations) of all tomatoes delivered to this processor during the four-year period. In the larger data set, some growers delivered only contract tomatoes and some growers delivered only no-contract tomatoes. We have found that quality incentives are not significant in the larger data set, in work not reported here. This difference suggests that the factors that determine delivered quality also influence contract choice.

Evidently, studies that rely on a single contract choice by each agent are likely to have their analysis contaminated by agent-specific factors that affect both contract choice and agent performance.

Our results showed that growers respond to price incentives in the predicted manner. Both the no-contract variable and the contract late season coefficients increased the share of limited use tomatoes, mold, Greens, and material other than tomatoes so that they reduced tomato quality. All the coefficients were significant except for the limited use tomato no-contract coefficient in the full sample regressions, both coefficients in the full sample Greens regressions, and the no contract coefficient in the corrected OLS MOT regression for 1996. Our testable hypothesis proved relatively robust across these four quality dimensions. Relative to studies that rely on a single measurable response, the multiplicity of measurable responses allows us to draw stronger conclusions.

Results for net soluble solids were less conclusive. In the equation for net soluble solids (NTSS), both coefficients were positive and were significant in the regressions for the full sample, indicating that for this particular attribute biological considerations dominated incentive considerations. For the 1996 subsample, both coefficients were negative and significant, indicating that in that year incentive considerations dominated biological considerations. The mixed results for NTSS were not surprising, since NTSS is a very costly attribute for growers to deliver. Reduced yield is the primary cost of increasing NTSS. Since our data set did not include information on acres or yield, we were unable to account for this cost. The inconclusiveness of our findings for net soluble solids suggests that unobserved costs or interrelated returns may dramatically affect conclusions regarding agents' responsiveness to incentives.

Overall, our findings suggest that incentive contracts do affect production decisions for agricultural growers in the manner predicted by economic theory. The nature of our data set allows us to draw this conclusion in a relatively clean analytical environment, without confounding factors.

Table 1: Stylized Tomato Production and Harvesting Process

STAGES	DECISION MAKER	QUALITY AFFECTED
<u>Pre-Planting</u>		
Set Planting Schedule	Grower and Processor	
Choose Tomato Varieties	Grower and Processor	NTSS, LU, Greens
<u>Production</u>		
Fertilizer/Water Regime	Grower	NTSS
Pesticide Applications	Grower with Processor approval	
Weather		
Rain		Mold
Heat		LU, Color
<u>Harvest</u>		
Time of Harvest	Grower and Processor	NTSS, LU, Greens, Color
Sorting		
Mechanical	Grower	LU, Greens, Mold, MOT
No. of Workers	Grower	LU, Greens, Mold, MOT
Speed of Harvester	Grower	LU, Greens, Mold, MOT

Table 2: Dependent Variable NTSS: Selected estimated coefficients ⁹

Variable (S.E.)	Full Sample		1996 only	
	Corrected OLS	SUR	Corrected OLS	SUR
Intercept	4.9397** (0.040759)	4.9541** (0.051682)	4.8208** (0.21393)	4.837554** (0.38789)
NC	0.15710** (0.027028)	0.15682** (0.028887)	-0.37036** (0.074713)	-0.356402** (0.11466)
LATE	0.086883** (0.030360)	0.085143** (0.03004)	-0.41551** (0.076318)	-0.400638** (0.11537)

Table 3: Dependent Variable LU: Selected estimated coefficients ¹⁰

Variable (S.E.)	Full Sample		1996 only	
	Corrected OLS	SUR	Corrected OLS	SUR
Intercept	1.3817** (0.14224)	1.361763** (0.185686)	-2.3515** (0.57691)	-2.375232* (1.367270)
NC	0.27189** (0.085705)	0.271562** (0.103452)	3.0644** (0.34475)	3.045142** (0.403182)
LATE	0.070419 (0.088603)	0.074962 (0.107589)	2.6768** (0.34040)	2.656300** (0.405661)
NIGHT	-0.33725** (0.016758)	-0.347714** (0.016475)	-0.28143** (0.031129)	-0.281277** (0.029776)

Table 4: Dependent Variable Mold: Selected estimated coefficients ¹¹

Variable (S.E.)	Full Sample		1996 only	
	Corrected OLS	SUR	Corrected OLS	SUR
Intercept	-0.47723** (0.12541)	-0.477127** (0.114612)	-0.30864 (0.25025)	-0.299941 (0.241123)
NC	0.29537** (0.079498)	0.294518** (0.073877)	1.0481** (0.25363)	1.035145** (0.240039)
LATE	0.55895** (0.074660)	0.559330** (0.076574)	1.0773** (0.25400)	1.062906** (0.242669)

Table 5: Dependent Variable MOT: Selected estimated coefficients ¹²

Variable (S.E.)	Full Sample		1996 only	
	Corrected OLS	SUR	Corrected OLS	SUR
Intercept	0.20023** (0.0088319)	0.200232** (0.009989)	0.25686** (0.022891)	0.258974** (0.017515)
NC	0.036229* (0.018273)	0.036229* (0.015243)	0.029058 (0.039051)	0.055412** (0.020843)
LATE	0.040258** (0.0059368)	0.040258** (0.005920)	-0.028060* (0.014768)	-0.034310** (0.011467)

Table 6: Dependent Variable Greens: Selected estimated coefficients ¹³

Variable (S.E.)	Full Sample		1996 only	
	Corrected OLS	SUR	Corrected OLS	SUR
Intercept	0.69536** (0.066134)	0.689459** (0.073638)	1.1061* (0.46392)	1.307888* (0.637979)
NC	0.034154 (0.031129)	0.030680 (0.041182)	1.0758** (0.13301)	1.022923** (0.188208)
LATE	-0.041821 (0.033244)	-0.031831 (0.042671)	0.98076** (0.13512)	0.927991** (0.189332)

APPENDIX: THEORETICAL MODEL

We develop a simple theoretical model that predicts how growers will respond to quality incentives. Our risk neutral tomato producers maximize profits per acre. Each producer's total revenues are a function of the base price, the quality price incentives he faces, the weight deductions he faces, the tons of tomatoes he delivers and the quality of the delivered tomatoes. His total costs are a function of the tons of tomatoes he produces and the quality of his delivered tomatoes. His maximization problem over the quantity and quality of tomatoes he delivers may be written as follows:

$$\max_{q, Q} Q(1 - w(q))(B + p(q)) - C(Q, q) \quad (6)$$

where q is quality, Q is quantity, $w(q)$ is the weight deduction schedule, B is the base price per ton, $p(q)$ is the price premium schedule, and $C(Q, q)$ is the cost function. For the component functions $w_q < 0$, $w_{qq} < 0$, $p_q > 0$, $p_{qq} = 0$, $C_Q > 0$, $C_{QQ} = 0$, $C_q > 0$, $C_{qq} > 0$, and $C_{Q,q} > 0$.¹⁴ This system is a simplification of the actual tomato price-quality relationship. The actual schedule includes minimum quality levels that must be met in order for the processor to accept the tomatoes. In practice, loads are almost never rejected due to failure to meet these standards, so this appears to be a reasonable simplification. The derivatives over the choice variables are

$$(1 - w(q))(B + p(q)) - C_Q = 0 \quad (7)$$

$$-Qw_q(B + p(q)) + p_q Q(1 - w(q)) - C_q = 0 \quad (8)$$

The first order conditions determine the equilibrium levels of q and Q for the grower. Equation (7) shows that the absence of price incentives for quality, $p(q)$, reduces the marginal benefit of producing quality without affect the marginal cost. Hence, quality will be lower when tomatoes are delivered for a fixed price.

We next consider the effect of a late season premium on quality. The late season premium is effectively an increase in the base price for late season tomatoes. Totally differentiating the first-order conditions, we obtain

$$0dQ + (-w_q(B + p(q)) + p_q(1 - w(q)) - C_{Q,q})dq + (1 - w(q))dB = 0 \quad (9)$$

$$(p_q(1 - w(q)) - w_q(B + p(q)) - C_{Q,q})dQ - (Qw_{qq}(B + p(q)) + 2Qp_qw_q + C_{qq})dq - Qw_qdB = 0 \quad (10)$$

The effect of a change in the base price per quality-adjusted ton, B , on the grower's optimal choice of quantity (yield) and tomato quality is

$$\frac{dq}{dB} = - \frac{(1 - w(q))}{-w_q(B + p(q)) + p_q(1 - w(q)) - C_{Q,q}} < 0 \quad (11)$$

$$\frac{dQ}{dB} = \frac{(w(q) - 1)(Qw_{qq}(B + p(q)) + 2Qp_qw_q + C_{qq})}{DET} + \frac{-Qw_q}{-w_q(B + p(q)) + p_q(1 - w(q)) - C_{Q,q}} \quad (12)$$

> 0

Both of these qualitative effects require $-w_q(B + p(q)) + p_q(1 - w(q)) - C_{Q,q} > 0$. This condition implies that a change in the marginal benefit of q (Q) due to a change in Q (q) is larger than the change in marginal cost. Provided that the condition is met, an increase in the base price of tomatoes will increase the optimal quantity of tomatoes and reduce the optimal quality. Unfortunately, our data set does not contain any information on acres harvested or yield, so we can not test any quantity response predictions.

NOTES

¹Information regarding tomato production and marketing was obtained from personal communications with Mark Evans, Jerry Gilbert, Gene Miyao and Woody Yerxa and from Sims, Zobel, May, Mullen and Osterli (1979) and Gould (1992).

²In contrast to government grading systems for other agricultural products, such as grains and beef, industry members, both processors and growers, are generally satisfied with the grading system. It measures relevant quality attributes in a reasonably accurate fashion. All contract price incentive payments are based on the results of the state grading.

³ A relatively small sample (100 pounds) is used to grade the quality of the 20+ ton load. Starbird (1994) examines the effects of the combination of a maximum worm percentage threshold and sampling have on growers' pesticide use decisions. He finds that the sampling process induces growers to use more pesticides than they would if every tomato in a load were graded.

⁴Joanne Hancock, CTGA, personal communication, October 21, 1999.

⁵We ignore the repeated nature of the grower-processor relationship. In practice, growers want to obtain contracts for the following year. Since the processor values tomato quality, the grower has an incentive to provide all high quality tomatoes, whether or not they are under contract this year. Even taking this incentive into consideration, there should still be a differential quality effect due to differences in current returns.

⁶Unfortunately, due to the lack of yield data we can not directly include this consideration.

⁷ These crop budgets are controversial in the industry due to the high per acre overhead costs they assign. When these costs are excluded from this calculation the grower would net over \$300 per acre before incentives.

⁸For example, an increase in the marginal incentive for low limited use (LU) tomatoes, coupled with a larger increase in the marginal incentives for Greens, may have a net effect of an increase in the share of LU tomatoes.

^{9**} significant at 1% level. * significant at 10% level. Regression information for full sample OLS regression with White-corrected standard errors: $R^2 = 0.3201$; Adjusted $R^2 = 0.3157$; Estimated variance (σ^2) = 0.15383; Sum of squared errors (SSE) = 5043.4; Mean of the dependent variable = 5.0939; Log of the likelihood function = -15830.9. Regression information for the full sample SUR regression: System weighted MSE 1 with 164154 degrees of freedom; System weighted R^2 : 0.2718. Regression information for 1996 OLS regression with White-corrected standard errors: $R^2 = 0.4169$; Adjusted $R^2 = 0.4111$; Estimated variance (σ^2) = 0.13561; Sum of squared errors (SSE) = 1234.9; Mean of the dependent variable = 5.1171; Log of the likelihood function = -3816.64. Regression information for 1996 SUR regression: System weighted MSE: 1 with 45624; System weighted R^2 : 0.3204.

^{10**} significant at 1% level. * significant at 10% level. Regression information for full sample OLS regression with White-corrected standard errors: $R^2 = 0.2674$; Adjusted $R^2 = 0.2626$; Estimated variance (σ^2) = 1.9727; Sum of squared errors (SSE) = 64674.; Mean of the dependent variable = 1.6515 ; Log of the likelihood function = -57928.4 Regression information for the full sample SUR regression: System weighted MSE 1 with 164154 degrees of freedom; System weighted R^2 : 0.2718. Regression information for 1996 OLS regression with White-corrected standard errors: $R^2 = 0.3311$; Adjusted $R^2 = 0.3244$; Estimated variance (σ^2) = 1.6737; Sum of squared errors (SSE) = 15239; Mean of the dependent variable = 1.4007; Log of the likelihood function = -15373.4. Regression information for 1996 OLS regression with White-corrected standard errors: $R^2 = 0.4169$; Adjusted $R^2 = 0.4111$; Estimated variance (σ^2) = 0.13561; Sum of squared errors (SSE) = 1234.9; Mean of

the dependent variable = 5.1171; Log of the likelihood function = -3816.64. Regression information for 1996 SUR regression: System weighted MSE: 1 with 45624; System weighted R^2 : 0.3204.

^{11**} significant at 1% level. * significant at 10% level. Regression information for full sample OLS regression with White-corrected standard errors: $R^2 = 0.3595$; Adjusted $R^2 = 0.3559$; Estimated variance (σ^2) = 1.0194; Sum of squared errors (SSE) = 33450.; Mean of the dependent variable = 1.3069; Log of the likelihood function = -47049.6. Regression information for the full sample SUR regression: System weighted MSE 1 with 164154 degrees of freedom; System weighted R^2 : 0.2718. Regression information for OLS regression with White-corrected standard errors: $R^2 = 0.3913$; Adjusted $R^2 = 0.3864$; Estimated variance (σ^2) = 0.79665; Sum of squared errors (SSE) = 7268.6; Mean of the dependent variable = 1.3525; Log of the likelihood function = -11968.7. Regression information for 1996 SUR regression: System weighted MSE: 1 with 45624; System weighted R^2 : 0.3204

^{12**} significant at 1% level. * significant at 10% level. Regression information for full sample OLS regression with White-corrected standard errors: $R^2 = 0.0862$; Adjusted $R^2 = 0.0857$; Estimated variance (σ^2) = 0.13223; Sum of squared errors (SSE) = 4361.4; Mean of the dependent variable = 0.24534; Log of the likelihood function = -13433.4. Regression information for the full sample SUR regression: System weighted MSE 1 with 164154 degrees of freedom; System weighted R^2 : 0.2718. Regression information for OLS regression with White-corrected standard errors: $R^2 = 0.1077$; Adjusted $R^2 = 0.1048$; Estimated variance (σ^2) = 0.14354; Sum of squared errors (SSE) = 657.83; Mean of the dependent variable = 0.27636; Log of the likelihood function = -2053.97. Regression information for 1996 SUR regression: System weighted MSE: 1 with 45624; System weighted R^2 : 0.3204

^{13**} significant at 1% level. * significant at 10% level. Regression information for full sample OLS regression with White-corrected standard errors: $R^2 = 0.2483$; Adjusted $R^2 = 0.2434$; Estimated

variance (σ^2) = 0.31768; Sum of squared errors (SSE)= 10415.; Mean of the dependent variable = 0.63065; Log of the likelihood function = -27797.1. Regression information for the full sample SUR regression: System weighted MSE 1 with 164154 degrees of freedom; System weighted R^2 : 0.2718. Regression information for 1996 OLS regression with White-corrected standard errors: R^2 = 0.2563; Adjusted R^2 = 0.2489; Estimated variance (σ^2) = 0.36944; Sum of squared errors (SSE)= 3364.1; Mean of the dependent variable = 0.71352; Log of the likelihood function = -8425.63. Regression information for 1996 SUR regression: System weighted MSE: 1 with 45624; System weighted R^2 : 0.3204

¹⁴The two assumptions $p_{qq} = 0$ and $C_{QQ} = 0$ do not change the qualitative nature of our comparative statics results relative to the more general cases $p_{qq} > 0$ and $C_{QQ} > 0$. If instead of $C_{Q,q} > 0$ we assumed $C_{Q,q} \leq 0$, our results would only be strengthened.

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