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**Effects of Price Premiums for Multiple Product Attributes on
Product Quality:
California Processing Tomatoes**

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One way for a processor to induce contract growers to provide products with desirable quality characteristics is to provide price premiums for specific, measurable attributes. In order for a processor to design the profit-maximizing contract, it is important to have an accurate estimate of growers' responses to financial incentives. Misjudging the effect of an individual premium, or a set of premiums in a single contract can be expensive. It can increase the cost of obtaining product with the desired attributes. It can distort overall quality away from the ideal portfolio of attributes, which in turn may increase processing costs, reduce revenues, or both. Such distortions will affect growers' returns from the contract, although the direction of the effect will depend on the specific situation.

While it is commonly believed that growers respond to price premiums, their actual behavior will depend on the incremental cost of increasing product quality in order to capture the price premium or avoid price discounts. If multiple price premiums are offered for different attributes, the net effect of the premium array on the entire set of product attributes is non-obvious.

We use data on four years of processing tomato deliveries to a single California plant to answer the following two questions: Do growers respond to price incentives? If so, how do incentives interact when incentives are offered for more than one quality attribute? Because of the biological relationships governing tomato quality and production, we expect there to be interactions among the choice of incentives, but the nature of the interactions will also be influenced by growers' profit-maximizing behavior, which in turn is affected by the incentives offered by the processor. In order to address our questions, we examine the interactions between the premiums for two important processing tomato quality attributes: limited use tomatoes and material other than tomatoes.

California Processing Tomato Industry and Institutions

Most processing tomatoes are quickly made into paste during the harvest season. The paste is stored for further processing (ketchup, tomato sauce, etc.) throughout the year. Prior to delivery to the processing plant, every load of processing tomatoes in California is legally required to be graded at a state inspection station. Each load is graded for seven quality attributes: a color score, the sugar content (soluble solids), and the percentage of each of five negative quality attributes: material other than tomatoes (MOT), limited use tomatoes (LU), mold, green tomatoes, and worms. Regardless of whether a load is sold under contract or on the spot market, it is subject to weight deductions for excessive levels of mold, greens, LU, worms, and MOT; that is, the grower may only receive payment for 1800 pounds of a ton of harvested tomatoes, if the quality is low enough to result in a 10% weight deduction. The quantity of tomatoes eligible for payment after the weight deductions is referred to as the quantity of *delivered* tomatoes. Below specified quality thresholds, the processor may reject the load and send it to be reconditioned. The grower is responsible for paying the reconditioning fee.

Industry members estimate roughly 97-98% of California processing tomatoes are delivered under contract.. The remaining 2-3% are spot market deliveries. Although the spot market's share of total deliveries is small, it is 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 restart, because the entire system must be reesterilized. Processors purchase spot market 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.

All contracts are negotiated between individual processors and the California Tomato Growers' Association (CTGA), a state-sanctioned collective bargaining agent. While fewer than half of the state's growers belong to the CTGA, processors are prohibited from offering a lower-price contract to non-members. Contract negotiations establish a base price and any price incentives for quality.

Price incentives represent processor efforts to achieve higher quality levels than those induced by the weight deduction system. Interestingly, the negotiations over price incentives address the expected share of price incentives in the total price per ton received for a load of tomatoes of "average" quality. The negotiations do not address the levels of incentives for individual attributes, or the attributes for which incentives are offered. Hence, by understanding the interactions between incentive instruments for different attributes on the delivered shares of those attributes, a processor can maximize her quality improvement through price incentives for any negotiated share of compensation for a load of average quality. In terms of incentive design, a processor must know whether incentives are substitutes or complements for a given attribute, not only the sign of the effect of each incentive on each quality attribute.

MOT and LU in Tomato Production

We focus on two tomato quality attributes: LU and MOT. LU denotes tomatoes that are overripe, often split or squashed, and so soft that their processing use is limited. MOT describes all material other than tomatoes that arrives at the processing plant in a load. MOT includes dirt, rocks, and vines. The shares of LU and MOT in the tomatoes delivered to the processor is affected by the grower's choices regarding variety, the timing of the harvest, and sorting practices during the harvest. A grower chooses the tomato variety prior to planting, often in cooperation with the processor.

The processor's scheduling needs influence the time of harvest, but the decision rests primarily with the grower. A highly skilled grower will time the harvest to maximize the share of ripe tomatoes and minimize the share of LU: Harvesting should start on the first day that 80 percent of the tomatoes reach maturity. The percentage of ripe fruit increases by three to four percent per day, but ripening speed increases at warmer temperatures. Harvesting too early will result in a low share of LU, but will have negative effects on the

production of other attributes. As the tomatoes ripen, controlling the share of LU becomes a material concern. A grower may choose to apply ethephon to speed ripening (subject to processor approval), 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 lasts as long as ten days for some varieties. Within the harvest window, a grower can reduce the share of LU by harvesting at night, rather than during the day. Because the temperature is lower at night, there will be a smaller share of LU in a load.

The grower makes a number of decisions regarding the sorting process which influence the quality of tomatoes delivered to the processor. First, the grower sets the sensitivity level of the mechanical sorter, which is particularly effective at removing MOT, as well as green tomatoes. 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 MOT, LU, and tomatoes with other undesirable characteristics. Up to a point, more workers increases sorting effectiveness, but 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. To some extent, effective sorting can offset grower mistakes in selecting the time of harvest. If the grower miscalculates the harvest timing, i.e. harvests too late when there is a large share of LU, or harvests too early when there is a large share of greens, the grower can still deliver high quality tomatoes by increasing sorting effort. However, his delivered tons will be fewer than if he had correctly timed the harvest and engaged in the same intensity of sorting effort.

The quality of delivered tomatoes is generally well-above the levels where weight deductions are applied. Most (95.3%) of the delivered loads are within the company's five percent tolerance for LU. Almost three-quarters (72.5%) of the tomatoes delivered contain two percent or less of LU. The company consistently receives very little MOT. Almost two-thirds (62.6%) of the delivered loads do not contain any MOT, and 97% of the delivered loads contain 1% or less of MOT. There are two possible explanations for why quality is generally well-above the weight deduction standards. First, it may be that growers can achieve the quality criteria of the plant, incurring little by way of cost in doing so. Second, growers may be responding to price premiums.

Relationship between Product Quality and Price Premiums

If growers indeed respond to price premiums, it is important to consider the effect of a premium for an attribute and on overall product quality. Because growers seek to deliver multiple quality attributes, if a processor offers premiums for two or more attributes there may be interaction effects on the grower's resulting response to the premiums. Similarly, a premium offered for one attribute may affect the provision of other quality attributes for which no premium is offered. A LU premium will affect a grower's choices regarding

variety, nighttime harvesting, and harvester speed. While the LU premium will reduce the share of LU in a delivered load, its effect on MOT is less clear. If the grower responded to the premium only by slowing his harvester, the MOT share would be reduced. However, unlike MOT, decisions other than harvester speed affect the LU share in a delivered load. The grower's decision to harvest at night will reduce the incremental gain of slowing the harvester; at any harvester speed, fewer LU will be delivered. Hence, the grower may actually increase harvester speed in response to an LU premium, because his other decisions regarding variety and nighttime harvest may reduce harvested LU, which in turn will reduce the benefit of slowing the harvester in order to eliminate more LU from the delivered load. If this were the case, we would expect an LU premium to increase the share of MOT in a delivered load.

Such cross-effects are of great interest to tomato processors, who choose price premiums in order to encourage growers to produce tomatoes with desirable quality attributes. If a MOT premium reduces LU as well, as predicted above, then it may be better to implement a substantial MOT premium rather than a MOT premium plus a LU premium, given the constraint on total expected incentive-based compensation. On the other hand, if a LU premium increases MOT, the processor may have to design an off-setting premium for MOT if it wishes to introduce a LU premium. If both a MOT premium and a LU premium reduce LU or MOT, the two incentive instruments may be complements or substitutes, which will affect the processor's returns from different menus of incentives.

In order to determine whether or not growers respond to price incentives, we examine the effects of LU and MOT premiums on the shares of these two negative quality attributes, and on a summary measure of other quality attributes, in delivered loads. We then test whether the premiums for LU and MOT complement each other, or substitute for each other in terms of their joint effect on the provision of LU and MOT.

Our test is dependent on variations in the premiums offered for low levels of LU and MOT during our four-year sample period. The contractual price incentives for LU tomatoes and MOT across the four years of our sample, combined with the presence of spot market loads, allow us to test for complementarities between the two premiums. In the first year, there was no MOT premium. In years two, three and four there was a premium for sufficiently low levels of MOT. There was a LU premium in years one, three, and four. Hence, our contracted loads provide us with quality observations associated with the presence of both a MOT and a LU premium (HH, years three and four), only a MOT premium (HL, year two) and only a LU premium (LH, year one). Our spot market loads provide us with quality observations in the absence of both premiums (LL, all years).

Descriptive Analysis

Table 1 reports means and standard deviations for MOT and LU for contract and spot deliveries by year. MOT did not vary much by contract regime and year. The consistently low levels of MOT may be due to the use of mechanical sorting during the harvest, and/or indirect effects of premiums for LU on MOT. As shown, LU did vary.

The lowest average LU for contract deliveries was realized in the year that there was no LU price premium. Because of the effects of weather on LU, it is not surprising that a simple annual average does not conform to theoretical predictions. In years one to three, contracted deliveries had noticeably lower levels of MOT and LU than spot market deliveries, while in year four the reverse was true. The annual standard deviations for the share of limited use tomatoes is larger than the standard deviations for MOT, possibly suggesting that growers are responding to changes in incentives, although there is no consistent comparison between contract and spot deliveries across years.

**Table 1. Average Percentage MOT and LU by Year and Contract Type
(Standard Deviations in Parentheses)**

	MOT		LU	
	Contract	Spot	Contract	Spot
Year One (LH)	0.25 (0.36)	0.55 (0.48)	1.96 (1.77)	4.13 (3.00)
Year Two (HL)	0.24 (0.37)	0.28 (0.40)	1.63 (1.57)	2.31 (2.78)
Year Three (HH)	0.25 (0.38)	0.31 (0.45)	1.66 (1.90)	1.78 (1.74)
Year Four (HH)	0.21 (0.35)	0.14 (0.26)	1.84 (1.64)	1.66 (1.41)

Summary of Statistical Analysis

Overall, our statistical analysis indicates that growers respond to price incentives for quality by delivering higher quality tomatoes. In order to determine whether or not growers respond to price premiums for quality, we quantify two empirical models. First, we used the premium levels in effect each year and the levels of each undesirable quality attribute for each load of tomatoes to construct a single premium and weight deduction-based measure of quality. In this case, growers responded to relatively small price incentives for reducing the share of undesirable attributes.

In our second model, we focused on MOT and LU, and constructed a third measure representing other negative quality attributes. We found that an incentive for MOT or an incentive for LU reduced MOT and LU. Harvesting at night reduced LU tomatoes, consistent with the role of temperature in determining the share of LU tomatoes. Loads with higher MOT tended to have higher shares of other negative quality attributes, consistent with the importance of sorting for determining MOT, as well as the other attributes.

We use our second model to examine the interaction effects between LU and MOT premiums on LU and MOT. We find that price premiums for lower percentages of LU and MOT are substitutable mechanisms to induce growers to provide tomatoes with less MOT. That is, either type of premium will reduce MOT, and there is no additional reduction in MOT that can be gained by offering a premium for MOT and a premium for

LU simultaneously, relative to the sum of the benefits of offering each individually. In other words, there are no synergies between the two premiums. In contrast, premiums for LU and MOT are complementary ways of inducing growers to provide tomatoes with lower LU. When both premiums are offered, there is a synergistic effect: the reduction in LU is greater in magnitude than the sum of the reductions in LU when each of the two premiums is offered on its own. These effects were statistically significant.

Conclusion

For this case study, growers responded to price premiums that rewarded them for delivering tomatoes with lower shares of negative quality attributes, which implies that the premiums were sufficiently high to cover the cost of improving quality. Our results show that incentives for one tomato quality attribute affect the delivered share of the other attribute. A price incentive for LU can substitute for a price incentive for MOT in lowering delivered MOT shares. In contrast, a price incentive for MOT complements a price incentive for LU in lowering delivered LU shares. Moreover, while a LU price incentive lowers MOT by a substantial amount, a MOT price incentive leads to a inconsequential reduction in LU.

Implications for Processors. For processors, our results suggest that in order to maximize returns from a contract with growers, a processor must consider the technical relationships governing the production of the valued product attributes values, and the cost of producing those attributes. In our specific analysis of incentives for LU and MOT in processing tomatoes, given that a processor must negotiate over the share of price incentives in the total price received for a ton of average quality tomatoes, our results suggest that allocating a relatively large share of that permissible incentive payment to rewarding low LU may increase delivered quality relative to allocating a relatively large share to rewarding low MOT.

Implications for growers. The difference in the effect of the relationship between the incentive provisions on the delivered levels of the two quality attributes in question is driven, at least in part, by the fact that reduced MOT is a much easier quality attribute for growers to provide than LU. When considering contracts with quality premiums, growers should assess whether the incremental cost of producing the quality needed to obtain the premium is at or below the premium. If multiple quality premiums are present, growers should consider whether making efforts to obtain one premium will make it more costly to obtain another.