# The New Volume Control: Strategic Enforcement of Minimum Quality Standards with Application to the Fresh Strawberry Market

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**Abstract**

Minimum quality standards (MQS) are common in agricultural industries, especially for produce commodities. Work to date on MQS has focused on standards imposed and enforced by governments or industries through marketing orders, geographic indications, and related organizations. In this paper we study MQS imposed and enforced by downstream buyers. We develop a conceptual model to show how such MQS can be used as a flexible tool by firms selling differentiated products and facing downward-sloping demands to control volumes in the face of demand or supply shocks. The model is tested empirically using transactions data for a large strawberry grower-shipper who operates multiple farms in California and Mexico.

Keywords: Contracts, Minimum quality standards, Modern agricultural markets, Strategic rejection

JEL Codes: Q13, L13

Minimum quality standards (MQS) are common for agricultural products and can be imposed to regulate a wide range of product attributes such as purity, presence of toxins, pesticide residue, ripeness or maturity, sugar content or brix, color, blemishes, and size. MQS may be imposed and enforced by governments, or such authority may be delegated to industry groups. In the United States MQS are often imposed and enforced by industries operating under the auspices of federal or state marketing orders (Bockstael 1984, Saitone & Sexton 2010) and in Europe by protected designations of origin or protected geographic indications (Lence et al. 2007, Menapace & Moschini 2024, Mérel & Sexton 2012, Zago 1999).

In modern supply chains, downstream buyers may also enforce quality standards. For example, the U.S. Perishable Agricultural Commodities Act (PACA) sets MQS for fresh and frozen fruits and vegetables. Under PACA, buyers are responsible for assessing product quality upon delivery and deciding whether to reject or accept a shipment. Sellers bear the cost of rejected shipments.[1] Downstream buyers may also impose and enforce their own MQS, which may be more stringent than any industry-wide standards, and, in addition to the aforementioned product characteristics, may include "credence attributes" such as the farming practices used to produce the product (Saitone et al. 2015). Such standards are similarly enforced by testing and inspections conducted by the buyer without third-party oversight.

Despite their increasing prominence in contemporary supply chains, quality standards set and enforced by buyers have not been studied extensively and involve unique issues relative to industry-wide standards set through government or marketing orders. Aside from regulating the intrinsic quality of farm product received by a downstream buyer, the rigor with which enforcement is exercised can serve as a volume-control device. Buyer-imposed and enforced MQS can be adjusted to help calibrate contracted production to market conditions.

[1] If a buyer rejects a shipment and the seller believes the rejection is unwarranted, the seller can schedule a USDA inspection to verify whether the product met the contract standards, but this provision is infrequently invoked.

Sellers of perishable product that is rejected by buyers may be unable to repurpose the product, resulting in such decisions contributing to food loss. Food loss pertains to production lost in the supply chain from harvest to retail. The United Nations (UN) estimates that 13% of potential food supplies are lost and another 19% is "wasted" at the retail, food service, and in households. The UN, European Commission, and U.S. Government have all called for reducing food loss and food waste by 50% as ways to improve food security reduce greenhouse gas emissions.[2]

Our goal in this paper is to study the role of buyer-enforced MQS as a volume-control instrument for perishable commodities. The basic idea is simple. In modern produce markets, buyers (shippers, processors, packers, retailers) contract to acquire production months in advance of the eventual harvest and the realization of demand. The quality of contracted product will be heterogeneous due to variations in weather conditions, growing practices, and intrinsic land quality. Demand and supply shocks in the period between contracting and harvest and sale can cause the contracted volume committed to a buyer to depart from the profit-maximizing amount to sell. Buyers can flexibly enforce the MQS, i.e., either tighten or relax the standard, to re-calibrate their inventories to the profit-maximizing amount to sell to consumers or other downstream buyers.

This approach to supply management is most important for perishable products for which storage is not an option and when spot or cash markets are not a viable option for sellers to recalibrate their supplies to current demand conditions. In modern produce markets active spot markets may simply not exist and, when available, are unlikely to be an effective mechanism for buyers to acquire product compliant with their quality standards.[3]

The idea that MQS can act as volume-control instruments is not new. In fact, the first discussions of MQS with the advent of U.S. marketing order legislation in the 1930s depicted

[2]The UN estimates that 8 – 10% of global greenhouse gases are associated with wasted food.

[3]Adjemian et al. (2016) provide several examples across different commodities that illustrate the limitations of spot markets as a tool for marketers to calibrate supplies with realized demands.

them as simply a "hidden" or indirect form of volume control (e.g., Wellman (1935)), a characterization that has continued through time (e.g., Carman (2007), Lence et al. (2007)), including in policy settings (US Department of Justice (1993, 1994)). The straightforward economic argument is that, by removing product from the market through the MQS, reduced sales will raise industry prices, revenues, and seller profits for a commodity with inelastic demand.[4]

Our argument regarding "the new volume control" is substantially different from this traditional explanation, heretofore unexplored, and reflective of the conditions which characterize modern agricultural produce markets (e.g., Goodhue (2011), Sexton (2013)), where contract procurement is the norm, product quality is a key determinant of demand, and spot or cash markets are not a viable trading option. Unlike prior analyses that have focused at the industry level, we study demands facing individual firms. Today's buyers of produce commodities, whether food manufacturers or retailers, are often differentiated sellers based on heterogeneous product quality, unique brands, geographic locations, etc. Such markets feature oligopoly or monopolistic competition structures, wherein individual sellers face downward-sloping demands for the products they sell (Ellickson 2007, Saitone & Sexton 2010).

The challenge for such sellers is to issue ex ante contracts with growers to procure the amount and quality of farm product necessary to maximize the seller's expected profits, given the specific final products they sell. Positive demand or negative supply shocks may render contracted volumes deficient relative to the optimum. Negative demand or positive supply shocks can cause contracted product to exceed the buyer's optimum sales volume.

In essence, produce buyers and sellers face a two-stage decision process. In the contracting stage buyers must calibrate their ex ante contract purchases based on the relative costs

[4]In a similar vein, Lowrey et al. (2023) show that retailers can use donations to food banks to increase on-shelf quality, soften price competition, and increase prices and profits. Their setting is distinct from ours in that the food bank donations consist of shelf-stable items that have already been "accepted" by the buyer.

of expanding acquisitions or selling less than the profit-maximizing volume in the case of negative supply shocks or positive demand shocks versus costs of product rejections or selling in excess of the profit-maximizing volume in the case of positive supply shocks or negative demand shocks. Importantly, these contract purchases will be made with in recognition of the degree to which the buyer can recalibrate product acquisition and sales at the time of harvest.

The terms of buyer-seller contracts in the produce industry are not public information, but they vary widely based upon our experience, including who bears financial responsibility for rejected product. For example, lettuce and cole-crop contracts often pay growers a fixed price per acre or hectare, and the buyer makes harvest decisions including whether to harvest the crop or disk it under and bears financial responsibility for unharvested product (Spalding et al. 2023). Others, such as the commodities regulated under PACA, which includes the fresh strawberry setting of our empirical analysis, allow buyers to make rejection decisions but make rejection the financial responsibility of the seller.[5]

The distinction of whether buyer or seller bears financial responsibility for rejected or unharvested product is not important in terms of the economics of this form of volume control. Any contract offered by buyers in a principal-agent context must meet sellers' participation constraints, which will include a probability of rejection when rejected product is a grower responsibility. By the same token, when contracts make rejected or unharvested product a buyer responsibility, the buyer's contract offer must incorporate the probability that the specific crop will not be harvested and sold. In either case we show that product rejection through more rigid enforcement of a MQS can be a superior strategy relative to the alternative of selling volumes that ex post are not profit maximizing.

[5]In the European Union, "Return of unsold products" is listed by the European Commission as a "grey" unfair trade practice, meaning it is "allowed only if agreed beforehand in a clear and unambiguous manner" (https://agriculture.ec.europa.eu/common-agricultural-policy/agri-food-supply-chain/unfair-trading-practices_en.).

In the following sections, we first set forth a theoretical model of flexible enforcement of MQS and optimal product rejection. The model involves a produce buyer as principal and growers as agents and unfolds across two stages. In stage 1 a buyer seeks to execute contracts with growers. All contracts must satisfy a grower participation constraint to reflect that growers will not accept any contractual arrangement that pays less on expectation than their best alternative option. If rejected product is a seller responsibility, rational sellers will anticipate that their production may be rejected by the buyer, and, thus, contract compensation must account for the probability that product will be rejected so that sellers' participation constraints are met. In stage 2 contracted production is realized as is the demand for the buyer's final product. Based on this information, the buyer may reject and not sell some of the contracted production.

We test the model using data on sales and rejections over a nine year period (2012-2020) for a large strawberry grower-shipper who sells directly to retail buyers using fixed price and quantity contracts. We find evidence consistent with our main theoretical prediction that rejections are responsive to market conditions. In particular, increases in the total quantity of strawberries produced increases the likelihood a shipment is rejected.

## 1 Conceptual Framework

We exposit the model in the simplest setting possible, but the key insights generated hold over more general market structures. A risk-neutral produce buyer competes to acquire farm product that is heterogeneous in its quality. Henceforth we refer to the buyer as the retailer, but the framework is applicable for other types of buyers who operate upstream from retail, such as branded food processors or fresh produce packers. The retailer faces a demand function for its final product that is decreasing in price and increasing in the average quality level of the product it sells.

We denote product quality by $\theta$, and assume the distribution of $\theta$ in the market at any

time is $f(\theta)$. To avoid complications associated with incentive compatibility constraints in the stage 1 contracting aspect of the model, we assume a grower's quality is fixed based on land quality and climate factors.[6]

The retailer's final product demand is also stochastic. For simplicity, we assume demand is subject to either a positive shock $\mu^+$ or a negative shock, $\mu^-$. The shocks are assumed to be equal in absolute magnitude and to each occur with probability $\rho = 0.5$. On average, the shocks cancel. Nothing of importance depends on these simplifying assumptions

We assume demand facing the retailer is linear and can be written in inverse form as:

$$P = a + b\overline{\theta} - q + \mu,$$

where

$$\mu = \begin{cases} \mu^+ : \rho = 0.5, \\ \mu^- : (1-\rho) = 0.5, \end{cases} \tag{1}$$

where $q$ is the quantity sold, and $\overline{\theta}$ is average quality of the retailer's product.The inverse demand slope with respect to sales volume is freely normalized to be 1.0 by choice of measurement units for quantity. The coefficient $b > 0$ measures the importance of product quality in determining the seller's demand. We also assume that one unit of farm product is required to sell one unit of final product.

In stage 2, the retailer has executed contracts from stage 1 to acquire $\tilde{q}$ units of farm product, and the decision problem in stage 2 is how many of those units to offer for sale, given the realization of the random demand shock, $\mu$. The retailer's costs include a constant per unit selling cost, $c$, to market the farm product, and its product acquisition costs. These costs are a function of the contracted quality. However, the role of these costs in the stage

[6]If quality is a function of cultural practices, then the stage 1 contracts are complicated by the buyer needing to incentivize growers to produce the product quality desired by the buyer.

2 selling decision depends on the nature of contracts. We model the scenario described by Spalding et al. 2023, wherein farm product procurement costs are sunk in stage 2 because growers have been guaranteed a fixed price for all contracted production.[7]

The retailer's stage 2 profit-maximization problem under this contract scenario is as follows:

$$\begin{aligned} \max_{q} \pi = [(a+\mu) + b\bar{\theta} - q]q - cq, \\ s.t.\ q \leq \tilde{q}, \end{aligned} \tag{2}$$

where the constraint reflects that the retailer cannot sell more than the contracted volume of purchases. Equation (2) yields first-order conditions:

$$\frac{d\pi}{dq} = (a+\mu) + b\bar{\theta} - q + (b\frac{d\bar{\theta}}{dq} - 1)q - c + \lambda = 0, \tag{3}$$

$$q - \tilde{q} \leq 0 \tag{4}$$

$$(q - \tilde{q})\lambda = 0, \tag{5}$$

where $\lambda$ is the Lagrange multiplier and $\frac{d\bar{\theta}}{dq}$ can be written as $(\hat{\theta} - \bar{\theta})/q$, where $\hat{\theta}$ is the quality of the marginal unit offered for sale, in which case the mean quality cancels from the expression and the FOC can be simplified to:

$$(a+\mu) + b\hat{\theta} - 2q + \lambda = c. \tag{6}$$

When the contracted quantity constraint does not bind in equilibrium so $\lambda^* = 0$, equation (6) simply reflects that the seller equates its marginal revenue from an incremental sale with its marginal costs of handling and selling the product. When the constraint does bind, $\lambda^* > 0$

[7]Under the PACA scenario, rejected product is not paid, so farm product costs are part of the retailer's stage 2 decision calculus.

and $q = \tilde{q}$. In this case marginal revenue exceeds marginal costs and profits are reduced from the unconstrained optimum.

The acquisition cost $p(\theta)$ is sunk and, thus, zero for the case where the buyer-seller contracts involve a fixed and guaranteed price. All else equal, sellers will sell more under this form of contract for any demand shock than under contracts where the grower bears the cost of rejection. However, under either contract setting the seller is constrained to sell no more than its contracted purchases.

Equation (6) clarifies that optimal quantity is higher under the positive demand shock, $\mu^+$, than the negative shock, $\mu^-$, because $q^*$ is increasing in $\mu$. If retailers face no repercussions for rejecting product, then their profit maximizing procurement choice in the first stage would be the optimal quantity under the positive demand shock, that is $\tilde{q}^+ = q^{*+}$. If, after procuring $\tilde{q}^+$ in stage 1, they realize the negative demand shock, $\mu^-$, they simply reject product at rate $r$ such that $q^{*-} = r\tilde{q}^+$. However, in reality, retailers are constrained in this rejection rate. Intuitively, if rejections are too high sellers will no longer contract with the retailer, favoring an outside option.

We address this by modeling contracting in the procurement market using a principal-agent framework: retailers offer contracts to sellers (farms) on a take-it-or-leave-it basis. Each contract consists of a fixed price offered to a farm $i$, $p_i(\theta_i)$, as a function of their quality. Consistent with the reality of modern produce contracts, the contract gives the retailer the option to reject the shipment on the basis of quality and the retailer does not pay for a rejected shipment.

Each contract must satisfy a farmer's participation constraint.[8] This means that the successful retailer must offer a contract with expected revenue to the farm that is at least as great as the outside option. We assume the outside option for all sellers has value $V \geq 0$,

[8]The incentive compatibility constraint that is commonly applied in principal-agent models is not needed here because both production quantity and quality are fixed.

which is not a function of quality and could, for example, be the value of selling the product to a food processor.

The expected revenue $R_i$ to farm $i$ consists of the fixed price offer, $p_i(\theta_i)$, less the probability that retailer will reject the shipment, in which case the farm receives zero revenue. Let this probability be $\bar{r}$, in which case expected per-unit revenue can be written as:

$$R_i = (1 - \bar{r})\ p_i(\theta_i). \tag{7}$$

We model these procurement arrangements so that each specifies the same units of product, which we normalize to one.[9] Thus, the retailer's price offer and rejection rates must be such that $(1 - \bar{r})\ p_i(\theta_i) \geq V \geq 0$ for all farms that they successfully procure from, $\tilde{I}$.

$$\begin{aligned} \max_q \pi = [(a + \mu) + b\bar{\theta} - q]q - cq, & \\ & \text{s.t.} \\ & q\bar{r} = \tilde{q} = \tilde{I}, \\ & (1 - \bar{r})\ p_i(\theta_i) \geq V \quad \forall i \in \tilde{I}, \\ & 0 \leq r_i \leq 1 \quad \forall i \end{aligned} \tag{8}$$

The retailer's first stage decision is to choose their procurement quantity, $\tilde{q}$, and equivalently the number of farms to contract with, $\tilde{I}$, prior to to realization of the demand shock $\mu$. In the second stage, the demand shock is realized and the retailer can choose how much quantity to reject, $\bar{r}$, and which farms to reject from, $r_i$. However, unlike the more simplistic version of the model, the rejection rate is now constrained by the farmer participation constraint. Further, because their downstream consumers are willing to pay a premium based on

[9]This is a reasonable simplification because retailers typically reject orders by the truck load. Further, it has few ramifications of our model since it does not prohibit farms from contracting with the retailer for multiple shipments, in which case $i$ indexes shipments rather than farms.

the average quality of product on their shelves, the farms they reject from are those providing the lowest quality product.

## 2 Data

The goal of our empirical application is to examine whether and how market conditions influence retail rejections. To to so, we combine data provided by a large agricultural firm with weekly market information from the USDA Agricultural Marketing Service (AMS).

Our sales data come from a large firm that produces strawberries on multiple farms in California and Mexico. The sales data consist of information on 35,721 strawberry shipments from 2012 to 2020. For each shipment, we observe the quantity (trays) of strawberries sold, the sales price, the date the product was shipped, the warehouse the berries were shipped from, and customer information including the retailer's name and location (distribution center).[10] For each strawberry sale, we observe whether the shipment was rejected by the retailer due to putative quality concerns.

Summary statistics for the firm sales data are shown in panel A of table 1. Over the span of our data, roughly 3.5 percent of orders were rejected by a retailer for quality reasons. Each order consisted of an average of 2,107 trays of strawberries, each containing either eight one pound clamshells or four two pound clamshells. This equates to approximately 16,900 pounds of strawberries per order. Two thirds of these orders were fulfilled with strawberries grown in California and the remaining one third were shipped from Mexico. Finally, these orders were shipped to 80 distinct retailers across the U.S. These retailers include leading U.S. chains such as Kroger, Walmart, HEB, Costco, Safeway, Trader Joe's, Sprouts, and Whole Foods.

We match these data to information on the strawberry market the week the product is shipped. We use the USDA AMS shipping point and retail sales datasets that consist of total weekly volume and mean weekly FOB prices of strawberries sold in California and Mexico,

[10]The data also include information on transactions with other types of buyers including wholesale and food service distributors, but we exclude them from the analysis.

and mean weekly retail prices in the U.S. We use this market data to construct measures of the weekly change in volume and prices to examine the impact of plausibly exogenous changes in market conditions on the likelihood of rejections for our strawberry producer.[11]

Summary statistics for the market data are shown in panel B of table 1. The mean weekly volume of conventional strawberry trays shipped from California and Mexico is 3.9 million, and ranges from 600,000 to 8.8 million over our study period. Mean weekly FOB prices for conventional strawberries are $11.5 per tray, or approximately $1.4 per one pound clamshell, and range from $5.5 to $25. Mean weekly retail prices are $2.6 per one pound clamshell, or roughly $21 per tray, and range from $1.8 to $4.6. We observe large week-to-week changes in total volumes shipped, ranging from a decrease of 3.1 million trays to an increase of 2.7 million trays, with the mean change indicating a weekly increase of nearly 2,600 trays. Week-to-week changes in FOB and retail prices are comparably small, with averages near zero. FOB price changes range from -7.4 to 7.4 per tray and retail price changes range from -2.2 to 2.5 per one pound clamshell.

Table 1: Summary Statistics

| | mean | sd | min | max | N |
|---|---|---|---|---|---|
| A: Shipments and Rejections Data | | | | | |
| Percentage of orders rejected | 3.48 | 0.0969 | 0 | 1 | 35,721 |
| Trays per order | 2107.5 | 1303.04 | 1 | 9,280 | 35,721 |
| Percentage of orders from CA | 66.61 | 0.2495 | 0 | 1 | 35,721 |
| Number of unique retailers | 80 | | | | |
| B: Market Data | | | | | |
| Total weekly volume (trays) | 3,879,084 | 1882200 | 591,834 | 8,814,604 | 468 |
| Mean weekly FOB price (per tray) | 11.52 | 3.65 | 5.5 | 25.11 | 468 |
| Mean weekly retail price (per 1 lb. clamshell) | 2.61 | 0.4158 | 1.84 | 4.56 | 456 |
| Change in weekly volume | 2,589.844 | 609090.1 | -3,125,404 | 2,691,890 | 467 |
| Change in weekly FOB price | 0.0008 | 1.6260 | -7.43 | 7.36 | 467 |
| Change in weekly retail price (per 1 lb. clamshell) | 0.0004 | 0.3334 | -2.2 | 1.46 | 455 |

Shipments and rejection data are described in panel A and include all orders to retail customers from 2012-2020. We observe 35,721 unique orders in this time frame. Percentage of orders rejected are the percentage of all orders with any rejected trays. Trays per order are the number of trays per sales order. Percentage of orders from CA are the percent of orders shipped from California warehouses, the remaining orders are shipped from warehouses in Mexico. The sales data include sales for 468 distinct weeks over the sample period. We match these data to weekly information on relevant strawberry market characteristics, including conventional strawberry volumes and prices (FOB) from all shipping points in Mexico and California and weekly retail price information for all U.S. markets. These market conditions are described in panel B.

[11]The quantity shipped by this firm to retailers in a given week accounts for 6 percent of total conventional strawberry shipments on average over the study period.

## 3 Empirical Framework

Our empirical strategy leverages plausibly exogenous changes in market conditions to study the effects of shocks in the retail market on the likelihood of shipment rejections. The main estimating equation can be written as:

$$\mathbb{1}(R_i) = \beta_0 + \beta_1 \Delta M_t + \mathbf{X_i'}\alpha + \lambda_y + \lambda_m + \lambda_b + \varepsilon_i \tag{9}$$

where $\mathbb{1}(R_i)$ is an indicator variable equal to one if order $i$ was rejected and zero otherwise, $\Delta M_t$ is the change in market conditions from time (week of sample) $t-1$ to time $t$, and $\mathbf{X_i}$ is a vector of controls for attributes of order $i$ (including the contracted quantity and, in years it is available, measures of strawberry quality), $\lambda_b$ a buyer fixed effect (for each unique retailer distribution center in the data), $\lambda_y$ a year fixed effect and $\lambda_m$ a month-of-year fixed effect. We consider three measures of market conditions: mean weekly retail price, mean weekly FOB shipping point price, and total weekly shipping point volume. We calculate the change in market conditions as the measure at time $t$, i.e. in a given week of the sample, minus the measure at time $t-1$, i.e. in the previous week. We match shipping point prices and volumes to the location of shipments: each shipment from a farm in Mexico (California) is matched to USDA AMS FOB price and volume data for all shipping points in Mexico (California) that week.

The parameter of interest is $\beta_1$ which gives the effect of a change in market prices or volume on the likelihood a shipment is rejected. Estimates consistent with our theoretical framework would be a *negative* $\beta_1$ for market prices and a *positive* $\beta_1$ for volumes. Coefficients in these directions would support the hypothesis that when there is a positive supply shock (lower prices and higher volumes) or negative demand shock (lower prices), retailers are more likely to reject shipments based on putative quality concerns.

# 4 Results

Results from the main specification are shown in table 2. The first two columns show results using changes in the mean weekly FOB shipping point prices in California and Mexico as the market condition of interest. Results are consistent with the theoretical framework and indicate that an increase in prices correlates with a decrease in the likelihood a shipment is rejected. After controlling for the year of the sample and customer characteristics, we estimate that a one dollar increase in the FOB price decreases the likelihood of rejections by 0.2 percentage points (column 2).

Table 2: Baseline Results

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $\Delta FOBPrice$ | -0.00341*** | -0.00283*** | | | | |
| | (0.000662) | (0.000596) | | | | |
| $\Delta RetailPrice$ | | | -0.00126 | -0.000514 | | |
| | | | (0.00347) | (0.00312) | | |
| $\Delta Volume$ | | | | | 4.19e-09*** | 3.50e-09*** |
| | | | | | (1.41e-09) | (1.27e-09) |
| $N$ | 35697 | 35697 | 35300 | 35300 | 35697 | 35697 |
| $R^2$ | 0.001 | 0.198 | 0.000 | 0.198 | 0.000 | 0.197 |
| Year FE | N | Y | N | Y | N | Y |
| Customer FE | N | Y | N | Y | N | Y |

The unit of analysis is an individual shipment. All columns show results from separate linear probability regressions of an indicator variable for whether the shipment was rejected on the relevant market condition. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Columns 3 and 4 show results using changes in weekly U.S. retail prices as the market condition of interest. The direction of coefficient is consistent with the theoretical framework, but the magnitude is small and not statistically significantly different from zero. This is likely due to stickiness in retail prices (Anderson et al. 2017, Chevalier et al. 2003, Nakamura & Steinsson 2008) and their stability relative to FOB prices (Li & Sexton 2013, Li et al. 2006, Russo & Goodhue 2018). As evidence on this in our context, mean weekly FOB prices have a standard deviation of 3.65 and a $20 spread whereas mean weekly retail prices have a standard deviation of $0.42 and a spread of less than $3.

Finally, columns 5 and 6 show results using changes in total weekly volume as the market condition of interest. Again, the direction (positive) of the coefficient is consistent with the theoretical model and indicates that positive supply shocks increase the likelihood that a shipment is rejected. After controlling for the year of sample and retailer characteristics (column 6) we find that an additional one million strawberry trays increases the probability of a shipment being rejected by 0.35 percentage points.

## 5 Conclusion

This paper has addressed the topic of how variable enforcement of minimum quality standards (MQS) can be used as a strategic volume-control device by retailers who have market power as sellers due to location, product or brand differentiation, etc. Even though sellers must be compensated for product rejections in order to meet a participation constraint, such rejections may nonetheless be profitable for sellers facing downward-sloping consumer demand functions.

Our empirical application to fresh strawberry sales finds support for the model predictions. Positive supply or negative demand shocks, as measured by higher shipment volumes or lower FOB shipping point prices are each associated with a statistically and economically significant increase in the rate of product rejection.

There are several important implications of this analysis. Perhaps most salient from a social welfare perspective are those related to food loss. In the context of our empirical application, most strawberries that are rejected by a retailer never reach an end consumer. After a rejection, the shipper attempts to recoup some of their lost revenue and mitigate food loss, but have few options for accomplishing this. They first attempt to locate and reroute the shipment to a nearby terminal market, selling as much as possible at a heavily discounted rate. In lieu of a terminal market, they next look for donation options and finally resort to discarding the product. Even for shipments rerouted to terminal markets, much of

the product is lost due to strawberry shelf life. These losses can be detrimental to natural resources and social and environmental sustainability (FAO 2013, 2019, IFAD 2019).

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