Quality Inspection, Adverse Selection and Trade in Perishable Commodities

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Abstract:

The quality of many goods and services may change randomly between the time of shipment and delivery, creating disputes over quality that can result in lemons-market equilibria. We investigate the potential of third-party inspections for such inefficiencies. We consider two types of inspection, ex post verification of quality in consignment contracts and ex ante certification in FOB contracts, which were instituted for fruits and vegetables in the U.S. when national markets were emerging. We show that both types of inspection can counteract misallocations of quality found in lemons-market equilibria. Buyers prefer ex post verification to ex ante certification while sellers prefer the reverse. Government provision of inspection services may be necessary for making provision of inspection services economically viable, and may be desirable for reducing inefficiencies due to the costliness of inspection. The U.S. experience may provide lessons for developing countries in creating marketing institutions to foster economic growth.

Quality Inspection, Adverse Selection and Trade in Perishable Commodities

Many goods and services are subject to random changes in quality during the time between shipment and delivery. Agricultural commodities are a prime example. Despite efforts to control quality during production (for example, by controlling the varieties grown, in-season production decisions like pesticide application, and timing of harvest), problems in ensuring quality may persist because most agricultural products are perishable, making it possible for on-farm quality to differ from delivered quality. For example, fruit may contain spores that are unobservable at the time of shipping, but blossom into mold during shipment. Grains may absorb moisture and insect eggs may hatch during shipment, reducing quality prior to delivery. When quality deteriorates stochastically in this manner, there will likely be disputes between sellers and buyers over quality that cannot be resolved without independent verification. In other words, it will not generally be possible to write self-enforcing contracts because even when quality is completely observable by either party, each agent's observation of quality is insufficient to determine whether its partner in the contract has complied with agreed-on contract terms. When uncontrollable stochastic factors account for a significant share of quality deterioration, such problems will persist even in repeated transactions.

Disputes of this sort plagued the U.S. fruit and vegetable industry during the early 1900s, when the national fruit and vegetable market was emerging, and eventually led to the legislation of government inspections of fruit and vegetable quality at shipping and delivery points. In the emerging national industry, a large share of the nation's fresh fruit and vegetables was produced in the Pacific Coast and shipped to intermediaries, nationwide, via refrigerated railcar. These long distance transactions were complicated by several factors. Fruit was perishable, and so shipped quality often differed from delivered quality. Transactions took place between parties

separated by long distances: buyers purchased fruit without observing quality and sellers were unable to observe delivered quality. The combination of these factors – natural perishability and adverse selection created by distance between buyers and sellers – made disputes over quality frequent occurrences.

The industry tried out various ways of resolving the marketing problems created by long distances and perishability. Initially buyers and sellers experimented with different forms of contract. Sellers preferred FOB contracts in which prices were agreed on prior to shipping. Buyers preferred consignment contracts in which prices were determined after delivery. The trade press indicated that fruit and vegetable quality was disappointingly low under both types of contracts. In the western U.S., industry groups created institutions aimed at raising and standardizing quality. Growers in California, for example, formed the California Fruit Growers Exchange, which trained growers to sort and pack fruit properly. All three West Coast states established grading standards providing uniform definitions of quality. Washington State went a step further by developing a state inspection service to certify shipped apple quality. Similar initiatives undertaken by Eastern growers were unsuccessful. Ultimately, Eastern growers turned to the federal government.

The federal government's response was the establishment of a set of five marketing institutions, two of which—inspections in the receiving market and at shipping point—were specifically designed to enforce quality in contracts (Dimitri). These efforts mirrored earlier forms of government intervention to regulate the quality of agricultural products. For example, in 1747, the Maryland Tobacco Inspection Act was passed to standardize tobacco quality (Schweitzer, 1980), and legislation created inspections to monitor dairy product quality in the

Quebec Dairy industry in 1905 (Dupre, 1990). Federal inspection of meat was established in 1890 in the U.S., and U.S. federal inspection of grain was established in 1916.

Inspection services for fresh fruits and vegetables–which remain active today–were set up on a fee for service basis. Industry members pay for inspection services through an assessment on each unit sold as well as through fees levied for each inspection undertaken. These services are largely self-financing, which suggests that the industry view these inspection services as creating value sufficient to defray their costs.

Third party verification, such as the quality verification provided by shipping point and receiving market inspections, has been shown to make contract enforcement feasible in certain cases. The bulk of the literature has considered ex ante verification (that is, certification by sellers) in cases where quality does not deteriorate. Costly, perfect certification of quality can suffice to replicate first best market equilibria (Viscusi). Costly, imperfect certification, however, only partially overcomes adverse selection problems (De and Nabar); it does so to a greater extent when the cost of verification is higher (Mason and Sterbenz). When quality is exogenous, the amount of quality information revealed by the certifier influences both the level of trade and distribution of rents (Lizzeri, 1999). If quality is under the control of the seller, however, the presence of the certifier increases the level of quality produced, but not up to the level of the first best (Albano and Lizzeri, 2001). Third party ex post verification of quality has not been explicitly addressed in the literature. Related literature, however, considers third party verification in a variety of settings. Auditing, one form of third party verification, may induce conformity with regulations, for example, taxpayer compliance (Reinganum and Wilde) or truthful cost reporting by a monopoly (Baron and Besanko). Costly, perfect verification can explain why insurance contracts might not completely share risk (Townsend). If there is no

commitment to costly verification, contracts designed by a better informed agent have a lower verification cost than do contracts designed by an agent with less information (Choe).

This paper uses a series of stylized models to investigate several questions suggested by the U.S. experience. Why did growers prefer shipping point inspections and FOB contracts? Why did buyers prefer receiving market inspections and consignment contracts? Under what conditions are inspections economically viable? These questions are of more than historical interest. In many developing countries and countries of the former socialist bloc, the inadequacy of institutions for supporting marketing is a major impediment to economic growth. The U.S. experience can be helpful for designing policies aimed at strengthening market development.

The paper proceeds as follows. We start by examining the functioning of markets operating under consignment contracts, investigating in turn the first best equilibrium, the lemons–type equilibrium that prevails without verification, and the equilibrium with third-party quality verification. We next analyze the FOB contract, again investigating the first best, the equilibrium without third-party verification, and equilibrium with third party quality certification. For each form of contract we discuss the distribution of income between buyers and sellers with and without costly verification as well as the extent to which verification overcomes adverse selection problems. We conclude with a comparison of the two forms of contract and a discussion of implications for marketing institutions.

General Model

Consider a set of one-time transactions between perfectly competitive, risk-neutral sellers and buyers. Each seller possesses one unit of fruit of quality q, which is perfectly observable. In the absence of (costly) independent verification, q is private information. The distribution of quality across sellers $G(q)$ and its associated density $g(q)$ are common knowledge. The

minimum quality is q^l and maximum quality is q^u. Each seller has a reservation price l(q), which equals the value of fruit of quality q in the local market. This reservation price is increasing in quality, $l'(q) > 0$. The quality of the fruit in the local market is not subject to random deterioration. It is common knowledge and exogenously given.

The value of the fruit in the national market, p(r), depends on its quality at the time of receipt, r. The relationship between received quality and value to the buyer, p(r), is common knowledge. Received quality r is perfectly observable to the buyer. In the absence of (costly) verification it is the buyer's private information. The value of the commodity is increasing in quality, $p'(r) > 0$. During delivery from the seller to the buyer, the fruit undergoes exogenous stochastic deterioration (and so moral hazard is not a factor). The probability that the quality of the commodity at the time of delivery is no greater than r, conditional on quality at the time of shipment q, H(r;q), and its associated density h(r;q) are common knowledge. We assume that quality cannot deteriorate to less than the minimum q and that quality does not appreciate during shipment. The upper support of H(r;q) is shipped quality q. Higher shipped quality is associated with a superior distribution of received quality, $H_q(r;q) = \partial H(r;q)/\partial q \leq 0$. In what follows, we concentrate on one case of economic interest, that in which the expected value of the commodity in the high value market, Ep(q) = $\int_{q^l}^{q} p(z)h(z;q)dz$, exceeds the reservation price l(q) for all q $\in$ [q^l,q^u]. To simplify the analysis of market equilibria, we make the further assumption that $\dfrac{\partial Ep(q)}{\partial q} > l'(q) \, \forall q \in [q^l, q^u]$, i.e., an increase in quality increases the expected high value market price more than the local market price. We make the further assumptions that the price of minimum quality in the national market exceeds the price of minimum quality in the local

market, and that price of maximum quality in the local market exceeds the price of minimum quality in the national market (see Figure 1).

We consider two forms of contract: a consignment contract in which the price paid to the seller by national market buyers depends on received quality and an FOB contract in which the price paid to the seller by national market buyers depends on shipped quality. In each case, we consider the contract both without and with independent quality verification. In the consignment contract with quality verification, the national market buyer reports delivered quality to the seller, who then decides whether to accept the buyer's report or whether to obtain a neutral third-party verification of quality. In the FOB contract with quality verification the seller decides whether to certify quality prior to shipping the product to the national market buyer. Throughout the analysis we assume that there is perfect competition among buyers that results in an equilibrium price paid to sellers equal to the true value of the commodity given reported quality on receipt.

Consignment contract

Consider first long distance sales made on consignment in which sellers ship fresh produce to commissioned merchants. The latter sell the produce on behalf of the growers, paying the growers the sales revenues less a commission. Reports in the trade press suggest that sellers tended to be highly dissatisfied with this arrangement, believing that merchants typically underreported the true value of shipments and were even prone to making false claims of having to dump merchandise that was actually high quality. These reports also suggest that buyers preferred consignment sales. The models that follow provide insight into both parties' perspective on consignment contracts. We present three transactions: the first best consignment

contract, the no verification consignment contract, and the consignment contract with quality verification.

The sequence of events is as follows. The seller decides whether to sell in the national or local market. If the seller selects the national market, she ships the produce to the buyer, and after delivery, receives a report of quality. Prices in the consignment contract depend on buyer's report of delivered quality, $p(\hat{r})$. The transaction can be described as a set of actions taken by the seller and buyer, and beliefs about the other player's actions. The beliefs, actions, and therefore, equilibria, vary by type of sale (that is, first best, no verification, and verification). An outline of the seller's and buyer's actions, beliefs, and strategy follows:

Seller's marketing decision	Ship to the national market if expected profits from national market sales exceed expected profits from local market sales.
Seller's inspection decision (for verification contract)	After receiving the buyer's report, the seller will order an inspection if the expected gain from doing so, less the cost of inspection, exceeds the price associated with the buyer's report.
Seller's belief about delivered quality	Ex ante, the seller knows the probability distribution of delivered quality r, H(r;q). After receiving the buyer's report of quality, the seller updates her belief (the form of the update depends on whether inspection is available).
Seller's belief about reported quality	Depends on whether verification is available (and is described more fully below).
Buyer's reporting decision	The buyer selects the report of delivered quality that maximizes profits.
Buyer's belief about shipped quality	Ex ante, the buyer knows the distribution of the

shipped quality $G(q)$. After receiving the shipment, the buyer updates his belief about shipped quality.

Buyer's belief about probability of inspection   Buyer forms beliefs by using knowledge of how seller makes inspection decision.

First Best Contract

In the first best, both delivered and shipped quality are known to the buyer and seller, and so neither is able to misrepresent quality.   Thus, the seller's marketing decision depends on whether the expected profit from shipping produce of a given quality to the national market exceeds the profit from selling in the local market. Shipping to the national marketis optimal if:

(1) $Ep(q) = \int_{q^l}^{q} p(z)h(z;q)d \geq l(q)$.

Given the assumptions about inverse demand for quality in the two markets, under complete information, in equilibrium all fruit will be shipped to the national market.

No Verification Contract

If verification of received quality is not possible, the seller has private information about shipped quality and the buyer has private information about delivered quality. As in the first best, the seller will choose to ship fruit to the national market if the expected profit from national market sale exceeds the expected profit from local market sale, or if

(2) $Ep(\hat{r}) \geq l(q)$.

Ex ante, the seller does not know the buyer's report of quality but does know the decision process the buyer follows when making the report. The buyer's reporting rule is to select the report that maximizes profits, or

(3) $\max_{\hat{r}} p(r)-p(\hat{r})$,

which is monotonically decreasing in $\hat{r}$. The optimal report is bound from below by q^l and above by r, the latter because the buyer's returns are negative for $\hat{r} > r$. When the buyer's report is private information and not verifiable, however, the buyer will always report receiving q^l and the equilibrium price paid to the seller will thus be $p(q^l)$. The seller's marketing decision thus reduces to a comparison of $p(q^l)$ and $l(q)$. In equilibrium, since $p(q^l) > l(q^l), l(q^u) > p(q^l)$, and $l'(q) > 0 \; \forall \; q$, there exits a q^m defined by $p(q^l) = l(q^m)$ such that quality in the interval $[q^l, q^m]$ is sold in the national market. In this case, the seller will ship to the national market if $q \leq q^m$ and will sell locally otherwise (see Figure 1). That is, quality will be misallocated: High quality commodities will be sold in the low value local market rather than the high value national market. Note that national market buyers will earn positive rent in this case because they pay less than the full value of commodities shipped.

Proposition 1: In the consignment contract without verification, quality is misallocated in equilibrium. Low quality in the interval $[q^l, q^m]$ is sold in the national market and high quality in the interval $[q^m, q^u]$ is sold locally.

Proposition 2: In the consignment contract without verification, national market buyers earn economic rent.

Verification Contract

Next consider the case where the commodity is sold under consignment in the high-value market and costly verification is available. The sequence of events in this case is as follows. First, the seller decides whether to ship the commodity to the high value market or sell for the reservation price in the alternative market. If the seller chooses to ship the commodity to the high value market, she receives a report of delivered quality from the buyer. The seller either accepts the report and receives the associated high value market price or orders a costly inspection that reveals true received quality.

Consider first the seller's inspection decision on receipt of reported received quality. The seller makes this decision by comparing expected profit with inspection and profit from accepting the buyer's report of delivered quality, $\hat{r}$. The fact that received quality is observed without error implies that verification is perfect, that is, that inspection reveals the true quality. Let m(r; $\hat{r}$,q) be the seller's posterior distribution over received quality given the buyer's report $\hat{r}$ and shipped quality q. Let R(r) be the set of possible levels of received quality r that corresponds to each report of quality $\hat{r}$. Then m(r; $\hat{r}$,q) = $\dfrac{h(r;q)}{\displaystyle\int_{R(r)} h(z;q)dz}$. Let c be the cost of an inspection. We assume that the cost of inspection is not prohibitive, specifically, that $c < Ep(q^u)$ $- l(q^u)$.

If the seller ships quality q, the expected net return with inspection equals $\displaystyle\int_{R(r)} p(z)m(z;\hat{r},q)dz - c$. The return without inspection is $p(\hat{r})$. The seller will find it profitable to order an inspection when the expected return from inspection exceeds the price associated with the reported received quality,

(4) $\qquad \displaystyle\int_{R(r)} p(z)m(z;\hat{r},q)dz - c \geq p(\hat{r})$.

Let $\psi(q,\hat{r})$ be an indicator of this inspection decision, taking a value of 1 if the inequality above holds (and an inspection is ordered) and a value of 0 otherwise. Let $U(q,\hat{r}) = \{q: \psi(q,\hat{r}) = 1\}$ be the set of shipped qualities for which a report of received quality $\hat{r}$ will trigger an inspection.

Next consider the seller's decision as to whether to sell in the high value market or the low value alternative market. Because deterioration is exogenously stochastic, the seller does not know received quality with certainty. However, the seller does know the buyer's decision

rule for reporting quality and can infer from it the probability that the buyer will report received quality $\hat{r}$ conditional on shipped quality q. Denote this probability $v(\hat{r};q)$. Then the seller will choose to ship to the high value market if the expected return from high value market sales given anticipated optimizing choice of whether to order an inspection $\psi(q,\hat{r})$,

$$(5) \qquad Ew^v(q) = \int_{q^l}^{q} \left\{ \mathbf{y}*(q) \int_{R(r)} (p(z)m(z;\hat{r}) - c)dz + [1 - \mathbf{y}*(q)]p(\hat{r}) \right\} v(\hat{r};q)d\hat{r} ,$$

exceeds the alternative market price l(q). Let $\delta(q)$ be an indicator of this shipping decision, taking a value of 1 if $Ew^v(q) \geq l(q)$ and 0 otherwise. Let $M(q) = \{q: \delta(q) = 1\}$ be the set of shipped qualities for which sellers expect selling to the national market to be more profitable than selling to the local market.

Now consider the high value market buyer's decision as to the report of received quality. The buyer observes received quality r with certainty but does not know shipped quality. She chooses the report of quality to maximize her profit. In doing so, she faces a tradeoff. Reporting received quality below the actual level allows her to earn rent by paying less than the full value of the commodity. Reductions in reported received quality increase that rent. At the same time, reducing reported received quality increases the likelihood that the seller will order an inspection, in which case the buyer earns no rent. The buyer's optimal report maximizes the expected rent.

Formally, the buyer can form a posterior distribution of shipped quality conditional on observed received quality j(q;r) using Bayes' Rule:

$$(6) \qquad j(q;r) = \frac{h(r;q)g(q)}{\int_{M(q)} h(r;s)g(s)ds} .$$

The buyer's posterior probability that a given report of received quality will not induce the seller to order an inspection, conditional on observed received quality, is

$$(7) \qquad K(\hat{r};r) = \int_{U(q,\hat{r})} \frac{h(r;q)g(q)}{\int_{M(q)} h(r;s)g(s)ds} dq$$

and the buyer's expected rent is

$$(8) \qquad p(r) - p(\hat{r})K(\hat{r};r) - p(r)[(1 - K(\hat{r};r)]$$

The first order condition for a maximum can be written

$$(9) \qquad [p(r) - p(\hat{r})]\frac{k(\hat{r};r)}{K(\hat{r};r)} - p'(\hat{r}) = 0.$$

Since $p'(r) > 0$ and $k(\hat{r};r)/K(\hat{r};r) > 0$, it follows that $p(r) - p(\hat{r}) > 0$ and thus that $r > \hat{r}$. It also follows that the set of reports of quality $\hat{r}$ given received quality r, R(r), will be optimizing, that is, $R(r) = \{r : \hat{r} \in \arg\max\{ p(r) - p(\hat{r})K(\hat{r};r) - p(r)[(1 - K(\hat{r};r)]\}\}$.

A perfect Bayesian equilibrium is a triplet $\{\hat{r}(r), \mathbf{y}(q,\hat{r}), \mathbf{d}(q)\}$ such that each element is the optimal response given the relevant signal (received quality for the buyer, the report of quality for the seller) and Bayesian formation of beliefs, as discussed above. Assuming such an equilibrium exists, the preceding discussion implies[1]

Proposition 3: With ex post verification the high value market buyer always underreports quality and, on the average, earns positive rent.

One implication of Proposition 3 is that the seller's ex ante expected return from a high value market sale, $Ew^v(q)$, will be less than the first best expected return $Ep(q)$ (for qualities greater than the minimum (q^l) because the first best does not involve an inspection cost and because, under the consignment contract, the buyer always underreports quality. As a result, the

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[1] This result follows because the seller always pays the cost of inspection, as the initial legislation specified. Today, the party paying for the inspection can be either the buyer or the seller.

equilibrium allocation of commodities under the consignment contract will generally differ from the first best.

To explore the nature of the equilibrium, note first that the solution to the buyer's optimization problem will not be unique, i.e., that there are multiple optimal reports of received quality $\hat{r}$ for each given received quality r.[2] As a result, the seller will be not able to deduce received quality r exactly from reported quality $\hat{r}$. As before, the seller's ex ante expected return from a high value market sale, $Ew^v(q)$, will be less than the first best expected return $Ep(q)$ because the first best does not involve an inspection cost and because, under the consignment contract, the buyer always underreports quality. Two possibilities arise. If the difference between $Ep(q)$ and $Ew^v(q)$ is sufficiently small (that is, less than $p(q^l) - l(q^l)$), then the equilibrium allocation under the consignment contract will be the same as the first best allocation. If the difference $Ep(q)-Ew^v(q) > p(q^l) - l(q^l)$, however, there will exist a critical quality q^v such that it will be profitable to sell produce of low quality $q < q^v$ in the local market while high quality produce ($q \geq q^v$) is sold in the national market. Summarizing, we have:

Proposition 4: With ex post verification, the equilibrium allocation of the highest quality commodities will equal that under the first best. The lowest quality commodities will be misallocated if $Ep(q)-Ew^v(q) > p(q^l) - l(q^l)$; otherwise, the equilibrium allocation will equal the first best for all commodities.

These possible equilibrium allocations of quality are illustrated in Figure 1.

Even though inspections will occur in equilibrium, reliance on commercial inspection services may be problematic. One would expect the fixed costs of inspection to account for a large share of the total cost of providing inspection services, since the principal requirements

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[2] A separating equilibrium does not exist. To see this, suppose first that there is a unique optimal report of received quality $\hat{r}$ for each given received quality r. In this case, the seller will be able to deduce received quality r exactly from reported quality $\hat{r}$. The seller will thus order an inspection whenever reported received quality $\hat{r}$ falls below a critical level $\hat{r}*$. The buyer will therefore report $\hat{r}*$, avoid an inspection, and earn a rent equal to the cost of

involve and keeping trained inspectors available on call to conduct inspections as the need arises. If the volume of inspections needed to sustain an equilibrium is sufficiently small, the inspection fees a commercial service would need to charge to remain economically viable could be prohibitively high (although any inspection service could exploit economies of scope to lower its fees by serving markets for numerous kinds of produce). More generally, as we have seen, higher inspection fees imply a greater likelihood and degree of misallocation of quality and greater rents earned by buyers, both to detriment of sellers. From this perspective, some government subsidization of inspection services might be warranted as a means of reducing market distortions.

FOB contract

The first long distance sales were made on an FOB basis. Reports in the trade press of the time indicate that growers had a strong preference for selling on an FOB basis over selling on consignment. Farmers lobbied for a federal shipping point inspection service for many years and FOB contracts quickly became the norm once that service was initiated. The following models provide insight into the expected benefits of the FOB contract to sellers and buyers. Three equilibria are shown: the first best FOB contract, the FOB contract with no verification, and the FOB contract with ex-ante quality certification. Contracts of this type have been investigated by Viscusi, De and Nabar, Mason and Sterbenz, and others.

The sequence of events is as follows. The seller decides whether to sell in the national or local market. If the seller chooses to sell in the national market, two possibilities exist. First, in the absence of quality certification, she reports quality, $\hat{q}$. Second, in the contract with

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inspection c. However, if the seller's optimal response is to never inspect, the buyer's best response is to masquerade as a lower type by underreporting quality.

certification, the seller either certifies or reports quality to the national market buyer. The buyer's and seller's actions and beliefs are outlined below.

Seller's marketing decision	The seller selects the market to sell in by comparing expected profits from national market sales to local market sales.
Seller's reporting decision	Selects the optimal report by maximizing expected profits.
Seller's certification decision (if available)	A national market seller will choose to certify quality if doing so is more profitable than selling uncertified fruit in the national market.
Buyer's belief about shipped quality	Ex-ante, buyer believes quality is $q \sim G(q)$. After receiving the seller's report of quality or the certifier's report, and learning of the seller's decision to participate in the sale, the buyer updates her beliefs about the seller's type to incorporate this new information.

First best FOB contract

The first best equilibrium is the same as that discussed in the consignment contract case. Perfect information about shipped quality and competition among buyers leads to an equilibrium national market price equal to the expected value of produce of quality q on receipt (conditional on shipped quality), Ep(q) = $\int_{q^l}^{q} p(z)h(z;q)dz$. Since under our assumptions Ep(q) > l(q) $\forall$ q, the first best equilibrium involves shipping all produce to the national market, as Figure 2 illustrates.

No verification contract

In the absence of certification, FOB contracts will be characterized by the familiar lemons market equilibrium. In this situation, the shipped quality of produce is private information, and the buyer knows only its distribution. The seller will choose a report of shipped

quality $\hat{q}$ to maximize expected profit, $\int_{q^l}^{\hat{q}} p(z)h(z;q)dz - l(q)$. Since $p'(.) > 0$, all sellers will

report the highest possible shipped quality, $\hat{q} = q^u$, i.e., sellers' reports reveal no information to

the buyer. Buyers will thus pay the average high value market price of all qualities shipped to

the high value market,

(10) $Ep^u(q) = \int_{q^n}^{q^c} \int_{q^n}^{s} p(z)h(z;s)g(s)dzds$,

where q^n and q^c are, respectively, the lowest and highest qualities shipped uncertified to the high

value market. Two types of equilibrium are possible. Note first that $q^n = q^l$ since $Ep^u(q^l) =$

$Ep(q^l) = p(q^l) > l(q^l)$. Thus, produce of the lowest quality will always be shipped to the national

market. If $Ep^u(q^u) < l(q^u)$, then $q^c < q^u$ will be defined by

(11) $Ep^u(q^c) = l(q^c)$.

In this case, which is illustrated in Figure 2, low quality produce will be shipped to the national

market while high quality produce will be sold on the local market. (Alternatively, if $Ep^u(q^u) >$

$l(q^u)$, then $q^c = q^u$ and thus all produce will be shipped to the national market. This case is not

illustrated graphically.)

Note that in either case growers there will exist a critical quality $q^s < q^u$ such that $Ep(q^s) =$

$Ep^u(q^c)$. Growers shipping produce of quality $q < q^s$ will earn positive rent because for them the

market price $Ep^u(q^c)$ exceeds the expected market value of their produce, $Ep(q)$. At the same

time, growers shipping high quality produce $(q > q^s)$ will receive a price less than the expected

market value of their produce.

These results can be summarized as follows:

Proposition 5: Under FOB contracts without quality certification, quality may be misallocated
between the two markets. High quality may be sold in the local market while low
quality fruit may be sold in the national market.

Proposition 6. Under FOB contracts without quality certification, growers with low quality
produce will earn positive rent.

Contract with shipping point inspection

Shipping point inspection is a means of certifying shipped quality. We assume that

certification is error-free and thus provides the buyer with perfect information about shipped

quality. Equilibrium in such situations has been studied by Viscusi, by De and Nabar, and

others. Competition among buyers will result in a price of certified produce equal to its expected

value on receipt conditional on shipped quality, $Ep(q)$. Assume that the cost of certification is

not prohibitive, specifically, $a < Ep(q^u) - Ep^u(q^u)$ and $a < Ep(q^u) - l(q^u)$, so that sellers with the

highest possible quality commodities will find selling in the national market with certification

more profitable than either selling either in the national market without certification in a lemons

market equilibrium or in the local market.

Note first that produce of the lowest possible quality will be sold uncertified in the

national market since, by assumption, $Ep^u(q^l) = Ep(q^l) > Ep(q^l)-a$ and $Ep^u(q^l) = Ep(q^l) > l(q^l)$. As

occurs without certification, two types of equilibrium are possible. First, if $Ep^u(q^u) < l(q^u)$, then

$q^c < q^u$ will be defined by $Ep^u(q^c) = l(q^c)$ and there will exist a critical quality $q^m < q^u$ defined by

$Ep(q^m) - a = l(q^m)$. In this situation, illustrated in Figure 2, produce of quality $q^l \leq q \leq q^c$ will be

sold uncertified in the national market, produce of quality $q^c < q < q^m$ will be sold on the local

market, and produce of quality $q^m \leq q \leq q^u$ will be sold certified in the national market.

Alternatively, if $Ep^u(q^u) > l(q^u)$, then $q^c < q^u$ will be defined by $Ep^u(q^c) = Ep(q^c) - a$ and q^m will

not exist. In this case, which is not illustrated graphically, all produce will be sold on the

national market. Produce of quality $q^l \leq q \leq q^c$ will be sold uncertified while produce of quality

$q^c \leq q \leq q^u$ will be sold certified. In either case some sellers of uncertified produce will earn rent

because the expected market value of their produce is less than the market price, as was the case in the lemons market equilibrium discussed above.

These results can be summarized as follows:

Proposition 7: Under FOB contracts with certification available, the highest quality produce will be certified and sold in the national market while the lowest quality produce will be sold uncertified in the national market. It is possible that medium quality produce will be sold on the local market, in which case certification reduces but does not eliminate misallocation of quality.

Proposition 8: Certification reduces but does not eliminate the rent earned by sellers of low quality produce.

FOB vs. Consignment Contracts

The models presented above examine two forms of contract with verification, a consignment contract with ex post inspection verifying received quality and an FOB contract with ex ante certification of shipped quality. We assume competitive markets in which sellers and buyers are risk neutral and in which sellers bear the cost of verification. Both types of contract can rectify the misallocation of quality occurring in lemons market equilibria, at least in part. Because verification is costly, however, some misallocation of quality may persist. Furthermore, because verification is costly, some agents may be able to appropriate rent.

The two forms of contract differ in terms of which sellers find them beneficial and in terms of how rent is distributed between buyers and sellers.

First, in equilibrium the two are used on different qualities of commodities. Ex post verification is used to verify buyers' reports of low quality, while ex ante certification is used to verify sellers' shipments of high quality. Thus, for example, producers of agricultural goods will find it optimal to verify reports that low quality was received but will certify shipments of high quality.

Second, sellers with high quality produce benefit from both ex ante certification and ex post verification while sellers with low quality produce lose from both. These differences suggest that the potential for industry self-organization to rectify adverse selection problems due to perishability depends heavily on high quality sellers' share of the overall market. Industries in which a large majority of sellers is able to offer high quality goods for sale will be more likely to be able to create their own inspection services without government intervention. Industries in which a substantial share of sellers is able to supply only lower quality goods will lack sufficient internal support for the creation of such institutions. In the U.S., for example, growers on the West Coast predominantly produced high quality fruit for national market sale and were able to institute grading standards and certification services at the state level. Many growers in the Midwest and East, in contrast, produced lower quality fruit; growers in these areas were never able to organize themselves to provide certification services. Thus, the analyses presented above suggest that government intervention will be needed to ensure that inspection and certification services are provided in cases where lower quality production is the norm. They also suggest that provision of these inspection services (together with adequate grading standards) will create incentives for improving the quality of perishable goods offered in long distance trade.

The models presented above also indicate that the distribution of rent differs significantly between the two methods of verification. Ex post inspection allows buyers to pay less than the social value of commodities they receive, on average. In some circumstances, ex ante certification allows sellers of uncertified commodities to receive a price exceeding the social value of the commodities they ship. As a result, one would expect buyers to prefer ex post inspection while sellers prefer ex ante certification. The U.S. historical record bears out this expectation: While receiving market inspections (which provide verification) were instituted

first, growers continued to pressure Congress until it subsequently enacted legislation creating certification services.

In both forms of contract, the costliness of inspection can prevent the achievement of a first best allocation. This suggests that reducing the cost of inspection by taking advantage of economies of scale and scope will help increase the efficiency of inspection services. The U.S. experience suggests that certification is likely to be less costly than verification. Certification inspectors specialize in a small number of related products while verification inspectors deal with a wider variety of products and thus require greater training and expertise. Certification inspectors also tend to handle larger volumes, reducing average fixed costs. Thus, current fees for inspections at shipping point are significantly lower than fees for receiving market inspections.

The analyses presented above also suggest that government subsidization of inspection services may be necessary, both to reduce inefficiencies caused by the costliness of inspection and, more fundamentally, to make inspection services economically viable. Inspection services have significant fixed costs due to the need to maintain a force of inspection personnel. As we have seen, the volume of inspections needed to sustain an equilibrium under verification of received quality may be too low to support a commercial service at reasonable cost. In contrast, ex ante certification of shipped quality requires inspection of all produce being certified and thus involves a higher volume of inspections. In the U.S., for instance, the costs of providing shipping point inspection services is entirely funded by user fees (costs include inspector salaries and other operating expenses) while the user fees collected for receiving market inspection services do not cover the costs of providing them. Even when the provision of inspection

services is economically viable, however, some degree of subsidization might be desirable since the degree of quality misallocation remaining is increasing in the cost of certification.

Conclusion

This paper has investigated the role of two marketing institutions, shipping point and receiving market inspections, in resolving disputes over quality of perishable commodities in long-distance transactions. We show that both ex ante certification (shipping point inspection) and ex post verification (receiving market inspection) can counteract perverse allocations of quality caused by adverse selection problems when quality verification is infeasible. We show that buyers prefer ex post verification while sellers prefer ex ante certification. We also show that sellers offering high quality merchandise benefit from either kind of inspection service, while sellers offering low quality merchandise may lose from ex ante certification, suggesting that industry may actually oppose government provision of inspection services under some conditions, even though the provision of these services is welfare-improving. Our results also suggest that government provision of inspection services may be desirable for capturing economies of scale and scope as well as necessary for eliminating inefficiencies due to the costliness of inspection. The theoretical results, combined with evidence from the history of the U.S. fruit industry, suggest that government provision of inspection services can be important in enabling the emergence of smoothly functioning markets for perishable commodities. The U.S. experience should thus be useful in helping developing countries and countries of the former Soviet bloc create marketing institutions that will permit greater, more expansive economic growth.

Price

Ep(q)

Ew^v(q)

l'(q)

l(q)

p(q^l)

q^l q^m q^v q^u Quality
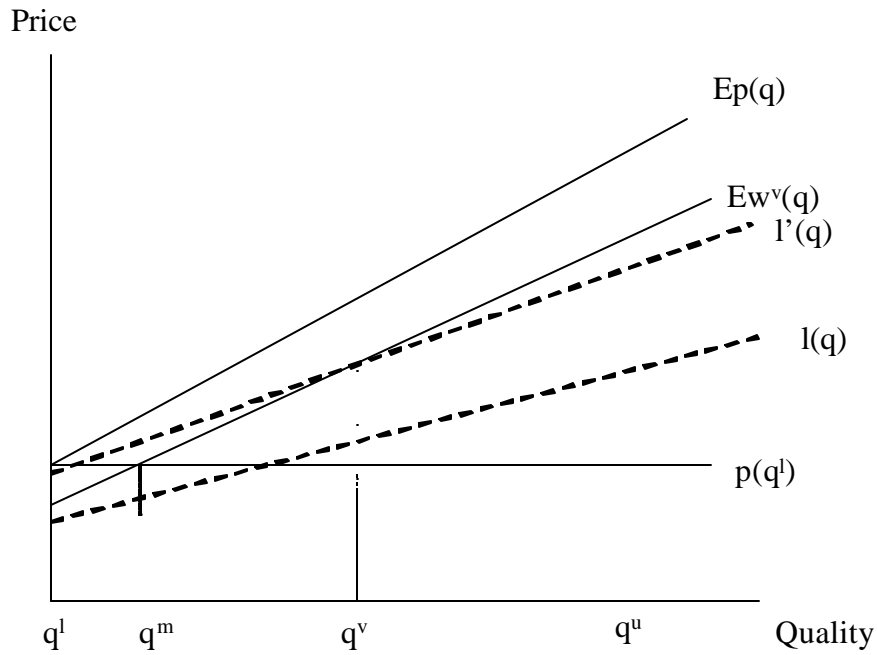
Figure 1: Comparison of First Best, No Verification, and Verification Equilibrium Consignment Contracts

Price

Ep(q)

Ep(q)-a   l(q)

Ep^u(q)

Ep^u(q^c)

q^l q^c q^m q^u Quality
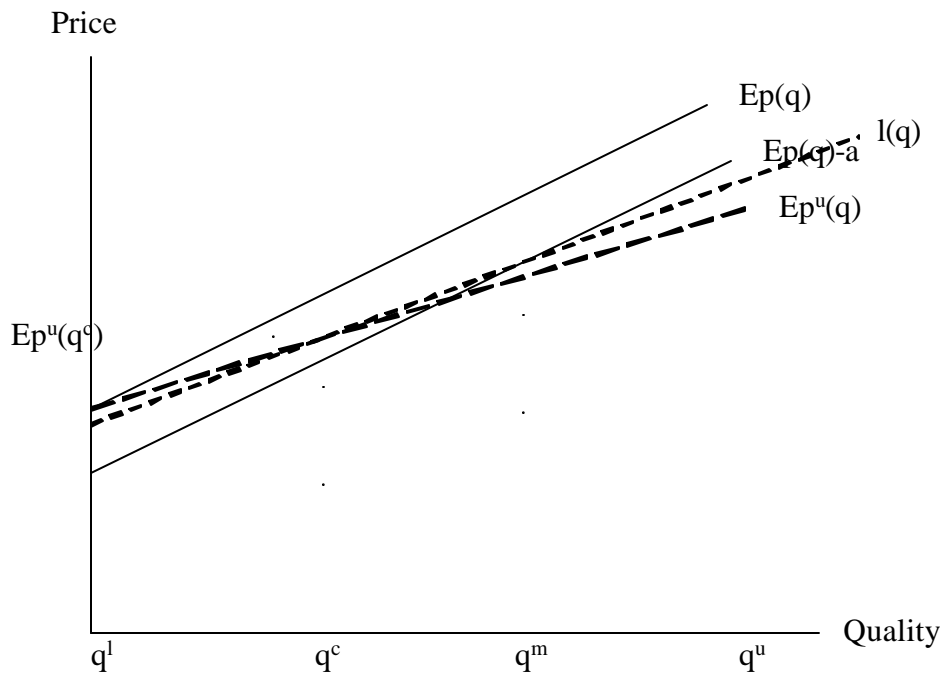
Figure 2. Comparison of First Best, No Certification, and Certification Equilibrium FOB Contracts

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