Markets with Untraceable Goods of Unknown Quality: Beyond the Small-Country Case

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Abstract

In markets for fruits, vegetables, and many imported goods, consumers cannot discern quality prior to purchase and can never identify the producer. Producing high-quality, safe goods is costly and raises the “collective reputation” for quality shared with competitors. By dropping the “small country” assumption in the trade literature on collective reputation, we show how large exporters like China, with its severe problems assuring the quality of its exports, can address its collective reputation problems.
1 Introduction

In many markets, consumers cannot evaluate the quality of a good before buying it. How can the pleasure of consuming a French brie or a California navel orange be judged without consuming them? How can the feel of a Bic ball-point pen be determined without writing with it? Consumers assess the quality of such goods by purchasing them repeatedly and eventually learn to anticipate their quality.

When the quality of a good cannot be discerned prior to purchase, we call it an “experience good,” a term coined by Nelson (1970). But there are really two distinct classes of experience goods. In the first, the consumer knows the identity of the producer. In the second, it is either impossible or too costly for the consumer to identify the producer. A Bic ballpoint pen belongs to the first class of experience goods. Behavior in markets where such goods are traded is well understood because of the contributions of Klein and Leffler (1981) and Shapiro (1983) in the IO literature and Falvey (1989) in the trade literature.

A French brie or California navel belongs to the second class of experience good, where the farm which produced the product is not apparent. Akerlof (1970) initiated investigation of this second class of experience goods but assumed firms could not adjust the quality of their merchandise. Subsequently, Chiang and Masson (1988) and Donnenfeld and Mayer (1987) in the international literature and Winfree and McCluskey (2005) in the IO literature allowed each firm to adjust the quality of its produce to maximize its profit. As each of these papers clarifies, producers of this second class of experience
goods are in a difficult situation. They know the quality of the goods they produce. But they realize that there is no way to distinguish the quality of their product from the quality of the other products lumped together in the consumer’s mind. They share a “collective reputation.” Not surprisingly, a producer does not have as much incentive to make a product of high quality as he would if consumers distinguished his products from those of his competitors.

Each paper in this literature has suggested remedies for this informational externality. Based on their model, Chiang and Masson (1988) propose consolidation of firms in the export sector since firms have stronger incentive to raise quality when the benefit is shared with fewer competitors. Based on their model, Donnenfeld and Mayer (1987) conclude that “a socially optimal policy requires control of both number of export firms and production scale of each firm. One way of affecting the firms’ production scale is to set well-defined export quotas for each firm.”

While these and other remedies make sense when exporters cannot affect the market price of their products, their value when producers of such experience goods have potential market power remains to be established. In this paper, we depart from Winfree and McCluskey (2005) in allowing firms to choose quantity and from Chiang and Masson (1988) and Donnenfeld and Mayer (1987) in allowing their quantity choice to affect the market price. This enables us to discuss the consequences of alternative remedies for the collective reputation problem when producers have the potential to wield market power.

This case seems relevant to international trade. Over the last decade,
China has exported toothpaste, cold medicines, toys, pet food ingredients, dry wall, infant formula and other products laced with lead, antifreeze, and other poisons. Undoubtedly Chinese firms would produce higher quality goods if there were a consolidation of firms as Chiang and Masson recommend and if each remaining firm was subjected to “well-defined export quotas for each firm” as Donnenfeld and Mayer advocate. But their policy recommendations were based on their small country assumption and were never intended for a country like China. In 2007, immediately prior to the Chinese pet food debacle, the Chinese had a substantial 10% share of the total U.S. gluten market. Then it was discovered that Chinese wheat gluten was tainted with melamine. In reaction, U.S. consumers switched to other suppliers, driving up prices on the U.S. gluten market by 30%. In another industry, China managed to raise the real price of cerium (a rare earth) from $6 a pound in 2008 to $170 a pound in 2011 by exactly the trade policy (export quotas) which Donnenfeld and Mayer recommend. “The Chinese,” as Robert Samuelson noted in a recent column in The Washington Post, “do not believe in free trade or fair trade. They practice fixed trade—fixed to benefit them at others’ expense.” Moreover, he points out that “by 2030, ...[China’s share of global trade] will reach 15%, twice the American share.”

We proceed as follows. Section 2 introduces the model and discusses existence issues. In Section 3, we investigate how regulating the quality of exports in a single country affects the international competitive position of firms in that country relative to firms in countries free from such regulation. Section 4 concludes the paper.
2 Model of International Trade

Suppose there are \( N \) countries. In country \( j \), \( n_j \) firms produce the experience good. The country in which a firm is located is known to consumers. Consumers form a view about the quality of the goods produced in a given particular country but cannot trace a good to a particular firm within that country.

The players in the game are the \( \sum_{j=1}^{N} n_j \) firms. Firm \( i \) in country \( j \) sets quality \((k_{ij})\) and quantity \((q_{ij})\) simultaneously. Since consumers cannot distinguish firms within country \( j \), every firm in a given country sells its experience good at the same price \((P^j)\) and their merchandise has the same reputed quality \((R^j)\). Given the strategy profile, \( \{k_{ij}, q_{ij}\} \) for \( i = 1, \ldots, n_j \) and \( j = 1, \ldots, N \), firms in country \( j \) develop a reputation for quality equal to the quantity-weighted average of their qualities:

\[
R^j = \sum_{i=1}^{n_j} \frac{q_{ij}}{Q^j} k_{ij}, \quad \text{where} \quad Q^j = \sum_{i=1}^{n_j} q_{ij}. \tag{1}
\]

Assume every consumer gets net utility \( u \) from purchasing one unit of the experience good of reputed quality \( R \) at price \( p \): \( u = a + \theta R - p \). Consumers can purchase a substitute which provides a reservation utility, and they buy the experience good if and only if it provides higher net utility than the outside option. Consumers are assumed to have the same parameters \( a > 0, \theta \geq 0 \) but to have different reservation utilities.

Consumers observe each country’s reputation for quality. The price they pay depends on the worldwide supply of the experience goods. Suppose
that, given the distribution of reservation utilities, a utility of $U(Q)$ must be offered to attract $Q$ customers to the experience good. We assume that $U(Q)$ is strictly increasing, strictly convex, and twice differentiable and that $U(0) = 0$. Price adjusts in each country so consumers are indifferent about the country from which they import the experience good. Every purchaser receives net utility $U(Q)$. Inframarginal buyers strictly prefer the experience good to their outside option while the marginal buyer is indifferent between the experience good and the outside option since both yield net utility $U(Q)$.

As a result, the inverse demand curve is additively separable, differentiable, strictly decreasing and strictly concave: $P_j(Q, R_j) = a + \theta R_j - U(Q)$, for $j = 1, \ldots, N$.

We assume that all the output of a given firm has the same quality ($k_{ij}$) and that each firm has a constant per-unit (and marginal) cost.\footnote{Since a firm would never choose to offer a portfolio of qualities given the strict convexity of its per-unit cost function, our assumption is unrestrictive. See the online appendix.} The per-unit cost of producing goods of the lowest quality is assumed zero.\footnote{Due to concavity, the inverse demand curve will hit the horizontal axis for sufficiently large $Q$. Price should remain at zero for larger values of $Q$. That is, technically $P_j = \max(0, P_j(Q, R_j))$. There will, therefore, exist trivial Nash equilibria in which every firm sets its quality to zero and $Q$ is large enough that the price in country $j$ is zero. As long as output is distributed among the $n_j$ (for $j = 1, \ldots, N$) firms so that no firm could raise price in any country $j$ above zero even if it cut its own output to zero, then every firm would earn zero and no firm could unilaterally deviate to strict advantage. Note that this only works under the assumption that producing nothing at the minimum quality is costless and is not robust to small perturbations in the cost function. Trivial Nash equilibria of this kind also exist in the Cournot model with strictly zero costs. We follow the standard convention of ignoring them.} The per-unit cost increases at an increasing rate if the firm chooses to produce higher quality products. In particular, $c(0) = 0, c'(0) = 0$ but $c'(k_{ij}) > 0, c''(k_{ij}) > 0$ for $k_{ij} > 0$.

Consider the game where each firm $i$ ($i = 1, \ldots, n_j$) in country $j$ ($j = 1, \ldots, N$)
1, \ldots, N) simultaneously chooses its output and quality to maximize the following payoff function:

\[ q_{ij} [a + \theta R^j - U(q_{ij} + Q_{-ij}) - c(k_{ij})]. \]  

(2)

We refer to the second factor in the payoff function as “per unit profit.” Whenever firm \( i \) in country \( j \) is inactive (\( q_{ij} = 0 \)), its profit is zero.\(^3\)

Since firm \( i \) maximizes profits, its pair of decisions must satisfy the following pair of complementary slackness conditions (denoted c.s.):

\[ q_{ij} \geq 0, \quad \{a + \theta R^j - U(Q) - c(k_{ij}) - q_{ij} U'(Q)\} + \theta q_{ij} \frac{\partial R^j}{\partial q_{ij}} \leq 0, \quad \text{c.s.} \]  

(3)

\[ k_{ik} \geq 0, \quad q_{ij} [\theta \frac{\partial R^j}{\partial k_{ij}} - c'(k_{ij})] \leq 0, \quad \text{c.s.} \]  

(4)

Using (1), we can evaluate the partial derivatives \( \frac{\partial R^j}{\partial q_{ij}} = q_{ij}/Q^j \) and \( \frac{\partial R^j}{\partial k_{ij}} = (k_{ij} - R^j)/Q^j \).

The terms in braces in condition (3) are standard. They reflect the marginal gain from selling another unit over the marginal cost of producing it. The term following the braces, \( \theta q_{ij} \frac{\partial R^j}{\partial q_{ij}} \), is novel and captures an additional consequence (beneficial or adverse) of expanding output marginally. If firm \( i \)'s quality is greater than the collective reputation of goods from country \( j \), then increasing output will raise the collective reputation of the good, which will increase the price. On the other hand, if firm \( i \)'s quality is below average, then increasing output will lower the collective reputation of goods from

\(^3\)Since \( R^j \) is undefined when \( q_{ij} = 0 \) and \( Q_{-ij} = 0 \), the firm’s payoff function is undefined at that one point. By defining the firm’s profit at that point to be zero, we restore continuity since for \( q_{ij} = 0 \), profit is zero for any \( Q_{-ij} > 0 \).
country \( j \), which will decrease the price.

The meaning of equation (4) is straightforward: if the firm produces no output, any quality is optimal; if the firm is active \((q_{ij} > 0)\) and quality is set optimally, then a marginal increase in quality must raise the per-unit revenue from sales of the goods by as much as it raises their per-unit cost of production.

In the appendix, we show that there can never be a Nash equilibrium in pure strategies where firms within a country behave differently. When every firm within country \( j \) makes the same pair of output and quality choices \((k_{ij} = k_j \text{ and } q_{ij} = q_j \text{ for all } i \text{ in country } j)\), equation (1) implies \( R_j = k_j, \frac{\partial R_j}{\partial q_{ij}} = 0, \text{ and } \frac{\partial R_j}{\partial k_{ij}} = 1/n_j \). Hence, the following conditions must be satisfied by the \( 2N+1 \) variables \((Q \text{ and } \{q_j, k_j\}_{j=1}^{N})\) in every Nash equilibrium:

\[
q_j \geq 0, \quad a + \theta k_j - U(Q) - c(k_j) - q_j U'(Q) \leq 0, \text{ c.s.} \tag{5}
\]

\[
k_j \geq 0, \quad q_j [\theta \frac{1}{n_j} - c'(k_j)] \leq 0, \text{ c.s.} \tag{6}
\]

and

\[
Q = \sum_{j=1}^{N} n_j q_j. \tag{7}
\]

The following theorem shows that there exists a single solution to these \(2N+1\) necessary conditions.\(^4\)

\(^4\)In footnote 2, we identified equilibria resulting in a zero price which we exclude as trivial. We also exclude solutions to (5)-(7) that arise because quality, although the same for any strictly positive output of the firm, is indeterminate when production is exactly zero. We do so by requiring that the firm choose the same quality when \(q_j = 0\) as it would when producing strictly positive output. In the absence of such a requirement, a firm could produce nothing at a quality so high that the cost of producing anything positive would exceed the revenue which could be gained, thereby satisfying the necessary conditions. We exclude such solutions. But even if we had included them as solutions, they can be ruled
Theorem 2.1 There exists a unique symmetric solution to the conditions necessary for a Nash equilibrium.

Proof If firms in country \( j \) are active \((q_j > 0)\) then condition (6) can be satisfied only by the unique quality choice making the factor in square brackets zero. If firms in country \( j \) are inactive, we assume that the firm chooses this same quality (see footnote 4). So we substitute \( k_j = c^{-1}(\theta/n_j) > 0 \), for \( j = 1, \ldots, N \) in the \( N \) equations of (5) and seek to solve (5) and (6).

Replace \( Q \) by \( X \) in condition (5). The unique solution to this condition can be written as the continuous function \( q_j(X) \geq 0 \). This function has a strictly positive intercept \((q_j(0) > 0)\), strictly decreases until it reaches zero and remains zero for larger \( X \).

Consider next \( \sum_{j=1,N} n_j q_j(X) \). This function of \( X \) must also be continuous with a strictly positive intercept. It must also strictly decline until it reaches zero and then must remain zero for larger \( X \). It follows that \( \sum_{j=1,N} n_j q_j(X) \) must cross the 45 degree line exactly once. At the unique crossing, \( \sum_{j=1,N} n_j q_j(X) = X > 0 \). Denote this unique fixed point \( Q > 0 \). By construction, given our solution of (6) there is a unique solution to (5) and (7).\(^5\)

Therefore, the only candidate for a Nash equilibrium is the unique fixed point in which all firms within a country make the same quality and quantity choices. We show now that:

\(^5\)The ideas underlying this proof originated in Gaudet-Salant (1991). It is straightforward to construct an algorithm which will quickly converge to the unique fixed point using interval bisection.
Theorem 2.2 Whenever firms in some country $j$ are inactive ($q_j = 0$) in the symmetric fixed point, there exists no symmetric Nash equilibrium.

Proof Suppose in the unique fixed point that $q_j(Q) = 0$ and $a + \theta k_j - U(Q) - c(k_j) - q_j U'(Q) \leq 0$ in some country $j$. We can rule out this solution as a symmetric Nash equilibrium by the following argument. If this condition were to hold, then since it is strictly decreasing in $q_j$, there can be no positive quantity choice that can satisfy the condition with equality for that same $k_j = c^{-1}(\theta/n_j) > 0$. Hence, a firm’s best reply to the other players’ strategy profile would be zero production. But a firm in country $j$ can strictly improve on that. Since $Q > 0$ there must be some country $h$ with strictly positive output and hence with $a + \theta k_h - U(Q) - c(k_h) = q_h U'(Q) > 0$. A firm in country $j$ could choose the same quality $k_h$, marginally increase its output above zero, and make a strict profit. Hence, the premise that there can be a symmetric Nash equilibrium with $q_j(Q) = 0$ must be false.

It follows that there can be at most one Nash equilibrium and in it every firm within a country behaves in the same way and is active ($q_{ij} = q_j > 0$ for all $i,j$). Even if every firm is active in the unique fixed point, firms in some country may be able to strictly improve their profits with a nonlocal, unilateral deviation. However, a unique Nash equilibrium always exists for sufficiently small $\theta$. This follows since when $\theta = 0$ the model collapses to the Cournot model with strictly concave inverse demand $P^j = a - U(Q)$. Since consumers do not value quality in this extreme case, firms would not incur the expense of providing it and the per unit cost of expanding output.

\[ \text{Since the solution satisfies the necessary conditions, no local unilateral deviation will be profitable.} \]
would be zero. Such a Cournot model is known to have a unique nontrivial equilibrium. By continuity it can be established that our model will continue to have a unique Nash equilibrium provided \( \theta > 0 \) is sufficiently small.

In characterizing the nature of this equilibrium, it turns out that the degree of competition within a country is of central importance, even though all firms compete on the world market and there is a single inverse demand curve faced by all firms.

**Theorem 2.3** Countries with a larger number of firms export lower-quality goods. Every firm within such countries exports less and earns lower profits than in countries with a smaller number of firms.

**Proof** Equation (6), which holds for firms in each country \( j \), implies that a country with a larger number of firms exporting the experience good (the “larger country”) will export lower-quality goods. Since prices adjust so that consumers are indifferent about the source of their imports, the exports of larger countries must sell for lower prices.

In the equilibrium any firm offering quality \( k \) earns profit per unit of \( a + \theta k - U(Q) - c(k) \). Since this function is strictly concave in quality and peaks at \( k^* \), the implicit solution to \( \theta = c'(k^*) \), in equilibrium every firm will choose a quality \( k_j < k^* \). Therefore, the profit per unit at each firm in a group rises if the common quality of every firm in that group increases. It follows that firms in larger countries will have lower profit per unit. But equation (5) implies that any firm with a lower profit per unit produces less output and hence earns lower total profit.\(^7\)

\(^7\)In this model, it is assumed that firms producing in one country cannot disguise
This result is intuitive. Since the quality reputation of an individual firm within a country is linked to the quality choices of its competitors in that same country, there exists a classic free-riding problem in which an individual firm has little incentive to invest in quality provision. A greater number of firms within a country exacerbates the severity of this collective reputation problem because the perceived marginal benefit of quality investment is inversely proportional to the degree of competition within a country. A lower collective reputation makes that country’s firms less competitive on the world market and therefore less profitable. In equilibrium, less profitable firms produce less and earn less gross profits. In the special case where every country has the same number of firms, quality, price, output, and profit are the same at every firm regardless of its location.

3 Potential Remedies

We now investigate potential remedies to the collective reputation problem. These can be divided into remedies that require international coordination and remedies that a country can pursue unilaterally. Given that consumers observe only the country of origin of the experience good but not the identity of the firm which produced it, we investigate the effects of giving each

their products as originating in another country where firms have a better reputation and earn higher profits. Presumably this implicitly requires that the government identify and prohibit such deceptions since they would be profitable. “Under EU law, for example, use of the word Champagne on wine labels is intended exclusively for wines produced in the Champagne region of France under the strict regulations of the region’s Appellation of Controlled Origin . . . Customs agents and border patrols throughout Europe have seized and destroyed thousands of bottles in the last four years illegally bearing the Champagne name, including product from the United States, Argentina, Russia, Armenia, Brazil and Ethiopia.” Castillo (2008)
consumer the information with which to classify more finely the source of the imported good. Consumers may be better able to better classify every firm in the world or merely better able to identify the firms from a single country. We also consider the qualitative impacts of a minimum quality standard on exports imposed by one country on firms within its borders.

3.1 Multilateral Remedies

Suppose consumers receive sufficient information to partition more finely the source of the imported good, regardless of its country of origin. Specifically, we have the following result:

**Theorem 3.1** Let $\mathcal{N}$ denote the worldwide partition of firms.\(^8\) Suppose a labeling program permits consumers to classify firms into a strict refinement $\mathcal{N}' \subset \mathcal{N}$ so that every firm is now assigned to a smaller group. Then quality, quantity, and profit will increase at every firm and the utility of every consumer of the experience good will increase as well.

**Proof** If every firm is a member of a smaller group, world production must increase. For, suppose it decreased. Then fewer consumers would buy the good, and it must provide lower utility. But since each firm shares its collective reputation with fewer competitors, every firm will increase its quality, and hence the reputed quality of its group will increase. But since profit per unit is increasing in the common quality of the group, the sum of the first four terms in equation (5) must increase. Since the second factor of the last term decreases, however, that equation would hold only if each firm’s

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\(^8\)In particular, $\mathcal{N}$ has $N$ subsets with the $j$th subset consisting of $n_j$ firms.
output \( (q_t) \) increased. But then world output would increase, contradicting our hypothesis.

Consequently, world sales of the experience good must strictly increase and hence so must production at each firm. Since each firm belongs to a smaller group, each firm will increase its quality. As for profitability, since both factors in the last term of equation (5) increase, net profit per unit (the first four terms of that equation) must increase. Therefore profit at every firm will rise. To absorb the increased production, the utility each consumer receives from the experience good must increase by enough to attract the requisite number of consumers away from their outside options.

Profits, and hence social welfare, would be higher if every consumer recognized not only that a product was imported from a particular country but also that it was made in a particular region of that country (or, better yet, by a particular ethnic group within that region). For, the smaller the number of firms in a category recognized by every consumer, the less incentive each firm will have to shirk in the provision of quality.

### 3.2 Unilateral Remedies

Coordination problems and political differences might make a worldwide labeling program difficult to implement. Instead a government might want to classify firms within its own borders unilaterally or alternatively to impose a minimum quality standard on the experience good its firms export. We will assume that such a standard \((\bar{k})\) is binding but is not set as high as a firm would choose if it were the only domestic producer. That is, we assume
\( \bar{k} < k^* \), where \( k^* \) solves \( \theta = c'(k^*) \). We establish that:

**Theorem 3.2** A finer classification of firms within a single country or the imposition of a minimum quality standard by one country raises the output and profits of its exporters while lowering the output and profits of unregulated exporters elsewhere. Overall, world output expands. Quality rises in the country in which the program originates and remains unchanged elsewhere. Both programs benefit every consumer of the experience good.

**Proof** The imposition of either the labeling program or the minimum quality standard by a single country \( i \) must strictly increase world production of the experience good. For, suppose the contrary. Suppose aggregate quantity falls or remains constant. Then the utility which consumers get from the experience good must weakly decrease. In every country \( j \neq i \), exporters would maintain quality since equation (6) still holds. So if their exports provide weakly less net utility, the prices of their exports (\( P_j^i = a + \theta k_j - U(Q) \)) must weakly increase. Since the per unit profit (\( P_j^i - c(k_j) \)) would then weakly increase, equation (5) implies that output at each such firm must weakly increase.

As for the firms in country \( i \), their per unit profit must strictly increase. If the country is able to more finely classify its firms on the world market, then each firm is a member of a smaller group and therefore produces a higher quality by equation (6). Alternatively, quality is raised at each firm by force of the binding minimum quality standard which, by assumption, was not excessive (\( \bar{k} < k^* \)) and therefore increases per unit profit. Equation (5) then implies that output at each firm in country \( i \) strictly increases. But
then we have a contradiction: aggregate output cannot weakly decrease as we hypothesized since that implies the sum of the individual firm outputs would strictly increase.

So the imposition of a either a labeling program or a minimum quality standard by a single country $i$ must cause world output of the experience good to strictly increase and hence must cause the net utility of every consumer of the good to increase. Since the quality of the firms in countries $j \neq i$ does not change, their prices, profit per unit, output and total profits must fall. Since aggregate output expands despite the contraction at every such firm, output at every firm in country $i$ must increase. But, as equation (5) implies, such firms would expand output only if their profit per unit also increased. Hence, their total profits would also increase. Since profit per unit increases at each regulated firm, its price per unit must increase by more than enough to offset the increased cost per unit of producing the higher quality.

Intuitively, both programs create a competitive advantage for the firms within the country implementing it and thus, ceteris paribus, disadvantages firms located in other countries. The labeling program alleviates the free-riding problem created by the collective reputation and the minimum quality standard reassures buyers about the quality and safety of products originating from that country. In effect, the minimum quality standard eliminates the strategic difficulties caused by collective reputation by force of regulation.\footnote{McQuade et al. (2010) extend the model above to a study of formal and informal markets in developing countries. The imposition of a minimum quality standard on the formal sector raises the output and profits of firms in the formal market while lowering the output and profits of unregulated firms in the informal market. In long-run equilibrium, migration of firms from the informal to the formal sector causes profit per unit, output, and qualities to equalize across sectors at the level specified by the standard.}
4 Conclusion

In this paper, we considered markets where consumers cannot discern a product’s quality prior to purchase and can never identify the firm which produced the good. We began by considering an international model in which the information set of consumers is the country of origin and the average quality of the experience good in that country. In the absence of any regulations, a country with a larger number of producers of the experience good will export shoddier products at lower prices. When buyers who care about the quality and safety of the products they purchase are able to classify producers into even finer partitions, firms are motivated to improve the quality and safety of their merchandise. As a result, both profits and welfare increase. A minimum quality standard can secure further benefits. If one country imposes such regulations, consumers benefit not only from the enhanced quality of that country’s exports but from the opportunity to buy other countries’ exports which sell for diminished prices despite their unchanged quality. The minimum quality standard imposed by one country raises the profits of the firms compelled to obey them and reduces the profits of competing exporters with the misfortune to be located in countries without such regulations.

Although we have focused here on the implications of collective reputation for international trade, the issue of collective reputation also has implications for domestic antitrust policy. The Department of Agriculture (USDA) has long advocated minimum quality standards for fruit and vegetables in recognition of the collective reputation problem which farmers face. The Department of Justice, however, regards all such minimum quality standards
as mere volume restrictions intended to benefit farmers at the expense of the consumers. For example, DOJ (Bingaman and Litan, 1993) objected to the minimum quality standards that USDA advocated for oranges, grapefruit, tangerines, and tangelos grown in Florida, for tart cherries grown in Michigan and for oranges and grapefruits grown in Texas. In future work, we hope to identify circumstances where such minimum quality standards would be welfare-improving and should be allowed.
A Asymmetric Nash Equilibria

In the text, we assumed that all firms in country \( j \) behaved in the same way (\( q_{ij} = q_j \) and \( k_{ij} = k_j \)). This led us to analyze conditions (5) and (6). In this appendix, we prove that there can be no Nash equilibria where firms within any country \( j \) behave differently. To do this, we must analyze conditions (3) and (4). We first establish through three lemmas that in any nontrivial Nash equilibrium\(^{10} \) every firm in every country is active (\( q_{ij} > 0 \)) and produces a quality above the minimum level (\( k_{ij} > 0 \)). Since the optimum for every country is interior, conditions (3) and (4) simplify and we prove that their unique solution has all firms within a country producing the same quantity at the same quality.

**Lemma A.1** There can be no non-trivial equilibrium in which a firm produces a positive quantity of the minimum quality (\( q_{ij} > 0 \) implies \( k_{ij} > 0 \)).

**Proof** If it is optimal to produce at minimum quality (\( k_{ij} = 0 \)), then since \( c'(0) = 0 \) condition (4) requires that \( \theta \frac{q_{ij}}{Q_j} \leq 0 \). But each of the factors to the left of this inequality is strictly positive since, by hypothesis, \( q_{ij} > 0 \). So the inequality can never hold. Therefore, every firm with \( q_{ij} > 0 \) must have \( k_{ij} > 0 \).

Intuitively, since the cost function is flat at the origin but inverse demand is strictly increasing in quality when the price is non-zero, an active firm producing a minimal quality can always increase his profit by marginally increasing his quality choice. At the margin, costs will remain the same but the price will increase.

**Lemma A.2** There can be no non-trivial equilibrium in which an active country can have an inactive firm (\( Q_j > 0 \) implies \( q_{ij} \) at every firm \( i \) in country \( j \)).

**Proof** Suppose that \( q_{ij} = 0 \) and \( Q_j > 0 \). In that case, one or more of the rival firms is producing a strictly positive amount. Label as firm \( i' \) the active firm with the smallest quality. Hence, \( k_{ij} - R_j^i \leq 0 \). Since firm \( i' \) produces a strictly positive amount, its first-order condition in (3) must hold with equality. Since the terms \( q_{ij} U'(Q) \) and \( q_{ij} \theta (k_{ij} - R_j^i)/Q \) are respectively strictly and weakly negative, (3) implies \( a + \theta R_j^i - U(Q) - c(k_{ij}) > 0 \). But then firm \( i \) could produce a marginal amount at quality \( k_{ij} \) and make positive profits. This a profitable deviation.

\(^{10}\)Conditions (3) and (4) (and, by extension, conditions (4) and (5)) hold only in non-trivial equilibria where inverse demand is not the zero function.
Therefore, we see that active countries cannot have inactive firms. Similar to Theorem 2.2, we may also show that there cannot exist Nash equilibria with inactive countries.

**Lemma A.3** There exist no non-trivial pure strategy Nash equilibria in which some countries produce no output \((Q^j > 0\) for every country \(j\)).

**Proof** Suppose that \(Q^j = 0\). Consider an active country \(h\) with collective reputation \(R^h\). If all firms within country \(h\) produce the same quality, then Theorem 2.2 applies. Suppose firms in country \(h\) produce asymmetric qualities. Then there exists a firm \(i\) in country \(h\) such that \(k_{ih} > R^h\). By assumption of Nash equilibrium, the unit margin of firm \(i\) must be non-negative. Since the cost function is strictly increasing, this implies that \(a + \theta R^h - U(Q) - c(R^h) > 0\). But then a firm in country \(j\) could produce a marginal amount at quality \(R^h\) and make positive profits. This is a profitable deviation. 

Given these results, we can show there exist no asymmetric Nash equilibria.

**Theorem A.4** There exist no non-trivial pure strategy Nash equilibria in which firms within the same country produce different qualities and/or outputs.

**Proof** If there is such an equilibrium, then by the three previous lemmas, the first-order conditions of each firm must hold with equality. That is, the following equations must hold in equilibrium for every country \(j\):

\[
\Gamma^j(k_{ij}; Q, Q^j, R^j) \equiv [k_{ij} - (R^j + \frac{Q^j U'(Q)}{\theta})]c'(k_{ij}) + \{a + \theta R^j - U(Q) - c(k_{ij})\} = 0. \tag{8}
\]

We will first show that it is not possible in equilibrium for any two firms in the same country \(j\) facing the same \(Q, Q^j,\) and \(R^j\) to have different qualities. The term in braces is the unit margin. It must be nonnegative or the profit in (2) would be strictly negative and the firm could deviate profitably to zero production. This implies that \(k_{ij}\) must satisfy:

\[
0 < k_{ij} \leq R^j + \frac{Q^j U'(Q)}{\theta}, \tag{9}
\]

where the strict inequality is a consequence of our three lemmas and the weak inequality follows since the cost function is strictly increasing \((c'(k_{ij}) > 0\) for \(k_{ij} > 0\)). In equilibrium, every firm \((i = 1, \ldots, n_j)\) in country \(j\) will have
\[ \Gamma^j(k_{ij}; Q, R^j) = 0. \] However, this equation cannot have more than one root over the relevant range. We see:

\[ \frac{\partial \Gamma^j}{\partial k_{ij}}(k_{ij}; Q, Q^j, R^j) = [k_{ij} - (R^j + \frac{Q^jU'(Q)}{\theta})]c''(k_{ij}). \]  

(10)

This indicates \( \Gamma^j(k_{ij}; Q, Q^j, R^j) \) is a continuous function and strictly decreasing over the interval \([0, R^j + \frac{Q^jU'(Q)}{\theta}]\). The claim therefore follows by Rolle’s theorem.

Hence, there can be no more than one root. So, for any given equilibrium with its \((Q, R^j)\) a unique \(k_{ij}\) satisfies equation (8). But since equation (8) must hold for every firm in country \(j\), each firm must choose the same quality in this equilibrium. Denote it \(k_j(Q, R^j)\). Moreover, since every firm will be active and reputed quality will equal \(R^j = k_j(Q, R^j)\), equation (3) implies that:

\[ q_{ij} = a + \theta R^j - \frac{U(Q) - c(k_j(Q, R^j))}{U'(Q)}. \]  

(11)

Since the right-hand side of this equation is independent of \(i\), every firm will produce the same quantity in this equilibrium. Denote it \(q_j(Q, R^j)\).
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