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Tainted Food, Low-Quality Products and Trade

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Abstract

This paper examines international trade in tainted food and other low-quality products. We first find that for a large class of environments, free trade is the trading system that conveys the highest incentives to produce non-tainted high-quality goods by foreign exporters. However, free trade cannot prevent the export of tainted products, and the condition for tainting to arise becomes more easily satisfied, if the marginal cost of high-quality production increases or if errors of testing product quality matter. We also examine cases of image-building investments and sabotage of rivals, and find that a tariff in either case reduces the foreign firm's incentives to produce high quality, which in turn tends to increase import tainting.

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1. Introduction

Media around the world abound with examples of malpractices in the daily running of international trade. In particular, headlines have alarmed consumers on the safety issues of imported products. Recently, it was revealed that some unscrupulous companies in China had routinely added melamine to milk to artificially boost protein readings in quality tests. Though imports from China have drawn the most criticism,[1] producers in other developing nations violate basic food safety standards as well (Mexican cantaloupe, Indian relishes, etc.). Furthermore, firms of developed countries have also been known for committing the alleged crime of using dangerous ingredients. For example, Morinaga Milk Industry of Japan added industrial arsenic to improve the solubility of dairy products around 1953; aniline was added to rapeseed oil in Spain in 1981; and most recently, it was found that Peanut Corp. America continued to sell their tainted peanuts and pastes for more than a year, even after the company knew the products tested positive for salmonella. As more goods from distant locations are increasingly traded internationally, the question of what determines the deviant behavior of enterprises assumes considerable importance.

An important factor affecting firms' behavior is consumers' preference for domestically made products over imported goods, especially when it comes to buying food. Consumers in richer countries discount goods made abroad, more so those coming from developing countries such as China and India. Thus, goods with the same attributes become differentiated by their countries of origin, and are priced differently. Given this, various governments and consumer organizations of nations relying on food imports have repeatedly put forward the view that the process of further globalization should be halted. Central to the

[1] Other cases include unapproved toothpaste, seafood containing antibiotics, deadly pet food, etc.

issue, is the popular conjecture that the global food crisis calls for more restrictions on international trade in order to increase consumption of local products.[2]

This paper examines the theoretical premises of such conjecture in a model of quality choice, with international trade involving tainted food and other low-quality products. We are especially interested in the conditions where foreign firms have incentives to produce tainted goods. In addition, we ask questions such as: (i) Does globalization via freer trade lower product safety? (ii) How does a firm's strategic behavior such as image building and sabotage affect rivals' export quality? (iii) And ultimately how is consumer welfare affected?

Consider two firms Home (H) and Foreign (F) competing in the home market. The foreign firm has access to two technologies, one producing a low-quality variant (e.g., tainted food in the present model) and the other producing high quality. A domestic health authority that controls quality of imports is only able to inspect a small fraction of total shipments. This inspection ratio is determined by the home government and known to consumers before they make their consumption decisions and to firms before they make their choices of output and investment in quality.[3] Given this, our setup is a sequence of moves and market structures that span over two periods. The foreign firm chooses the optimal quality strategy by maximizing the expected net present value of profits across qualities. Of these two technologies, which one is selected is private information of the foreign firm only.

The obvious problem with food or other goods that are imported is that consumers are not sure about their quality. Sellers could signal quality in various ways, however, there is still no guarantee that they do not over report or even lie about quality. We believe that

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[2] In Japan, a government survey conducted in September 2008 found that 89 percent of respondents said they would choose domestically produced products over imports; 93.2 percent said that Japan should be more self-reliant in procuring foodstuffs (The Daily Yomiuri, November 16, 2008).

signaling is more appropriate when higher quality is involved. In the present paper, since we deal with lower quality and tainted goods, it is natural that sellers would not want to signal or be signaled as "tainted". Furthermore, in the context of lower-quality imports from developing countries into developed countries, experience seems more trustable than *foreign* promises or signaling. In fact, many Japanese critiques say that in a series of imported food incidents that occurred in the past three years in Japan, only consumption experience mattered. That is, even official inspections failed. Thus, instead of the signaling approach that has been used in an international context,[4] we adopt a different approach, namely, experience goods. The foreign firm's investment determines the quality of its product, but its quality becomes observable to consumers only through experience with the product, or by obtaining a certificate of quality issued by inspection authorities in the domestic country. This approach seems more realistic for imported goods from poor countries to rich countries, where consumers in the latter countries usually believe that home made products are of higher quality, and foreign made goods are sold at home because of their much lower prices, instead of higher quality.[5]

Inspection at the customs with a cost paid by the exporter could be considered a special type of signaling, which we examine in detail in the model. As we shall show later, the punishment for tainting ('death penalty` in the second period) is much severe with the experience approach than with regular signaling (where enforcement of penalty is often a

[3] For example, it is known that the US Food and Drug Administration checks only 1% of all shipments bound to the US market. In Japan, about 11% of imported goods are inspected (The Japan Times Online, Nov. 26, 2008).

[4] For papers on signaling quality of imports, see Bagwell and Staiger (1989), Qiu (1994), Shy (2000), and Daughety and Reinganum (2008) among others.

[5] In the literature, Nelson (1970) is the first to systematically analyze the differences between experience goods and search goods, and makes some predictions about consumer behavior and market structure with the two types of goods. Under experience goods, Chen shows that an R&D subsidy characterizes optimal infant industry intervention, and it can also help individual firms to appropriate the benefits of quality-enhancing investments. Bergès-Sennou and Watson focus on product

problem when lying is detected). Even under these circumstances, tainted imports cannot be excluded. Nevertheless, signaling could be the approach to take if we study the case of two competing importers from developing countries, without a firm from a developed country that always produces higher quality.

We first find that for a large class of environments, free trade is the trading system that provides the highest incentives to produce non-tainted high-quality abroad. In the present model of experience goods, under an import tariff, the foreign firm's profits are reduced for one period if it exports tainted goods (which cannot be sold in the second period), but for two periods if it produces high-quality goods. Under normal conditions profits are lowered more by the tariff with high-quality production than with tainted goods, which in turn reduces the foreign firm's incentives to produce high-quality goods. However, free trade is neither a necessary nor a sufficient condition to exclude trade in tainted products.

The condition for tainting to arise is more easily satisfied if the marginal cost of high-quality production increases and low quality is always produced if this marginal cost is sufficiently high. Likewise this condition is also more easily satisfied if errors of testing matter. The intuition can be roughly understood as follows. Some testing errors (the so-called Type I) harm the foreign exporter because its high-quality exports are prohibited after inspection. Other errors (the so-called Type II) are a tragedy from the domestic society's standpoint, since inspectors mistake tainted goods for high-quality ones. Obviously the latter errors benefit the foreign exporter when he produces low-cost tainted goods.

The basic setup is then enlarged to cover cases where the foreign firm invests to enhance consumers' perception of its products (i.e., image building). Then the result that free

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labeling issues and show that for products purchased infrequently, introducing a reputable private label is unsustainable.

trade provides the highest incentives for high quality production is reinforced, the reasoning being that freer trade allows the foreign exporter to capture more rents from image building. Another interesting case is sabotage by domestic competitors, which arises more often when foreign imports are of high quality (low-quality imports will die in the second period and thus need not be sabotaged). We find that more tainting arises if an import tariff is imposed which would lower the domestic rival's cost of sabotage and increase its sabotage activities. This in turn allows the domestic firm to strengthen its leadership in high-quality production and gain market power. Consumers on the other hand have the most to lose.

Our results are closely related to the stylized observation that industrialized countries generally maintain relatively high tariff and nontariff barriers in agriculture and in processed food sectors. According to the World Bank (2001), average protection in those countries was about nine times higher for agriculture than for manufacturing imports. Though tariffs have decreased in recent years, nontraditional impediments such as health, technical and sanitary standards have replaced them, and compliance to these standards imposes additional costs on exporters from developing countries. Moreover, agricultural subsidies to member countries such as those in the EU and NAFTA countries worsen the situation. The present model implies that tainting is more severe in agriculture than in manufacturing imports; and an effective way of reducing tainting is to lower tariff as well as non-tariff barriers, contrary to the conventional wisdom that more import restrictions should be imposed. One obvious way to reduce tainting is to increase inspection. However, due to type I and type II errors and especially the high cost of inspection (such as canned food or fresh produce), this often may

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However, more retailer bargaining power increases the likelihood of a private label good being marketed.

not be feasible. Lowering barriers is perhaps necessary when in practice governments cannot raise import inspection due to various constraints related to budget, personnel, or technology.

Welfare analysis is complicated in this model because in the presence of tainting there is a difference between ex ante and ex post welfare, and how much welfare suffers ex post depends on how poisonous the tainted product is. However, the following point is clear: if the degree of tainting is not too high, then importing low-quality goods may yield higher welfare than importing high-quality goods when the latter are too costly to produce.

The paper is organized as follows. Section 2 lays out the setup of the model. Section 3 derives demand functions when consumers differentiate goods by country of origin. Section 4 calculates expected profits across qualities and examines the conditions under which tainted food is imported. Sections 5 to 7 analyze extensions of the model to include errors of testing, image investments and sabotage. Section 8 looks into domestic welfare and how it relates to model parameters. We conclude in Section 9.

2. The Basic Setup

Our framework consists of a domestic (H) and a foreign (F) producing firm that serve the domestic market only. The setup is a sequence of moves and market structures that span over two periods, period 1 and period 2. Panel (a) of Table 1 describes the case when firm F chooses to produce low quality. In the basic model we consider low quality to be synonymous with being tainted and poisonous, and relaxations will be discussed in detail in the conclusions. Local health authorities inspect imports with exogenous probability μ. Initially we assume that authorities can always tell if a good is non-tainted after inspection. Later in Section 4 we examine errors of testing, when inspection fails to uncover tainting. Given that firm F produces low-quality goods, if its exports are inspected, then the shipment is not allowed to enter. If not inspected then firm F's exports are sold into the domestic market. As consumers cannot observe the quality of the imported good, they experience its quality instead by consuming the good in period 1 and then learn that it is of the low-quality type. With this experience they decide not to consume the low-quality good in period 2.

Panel (b) of Table 1 describes the case of firm F producing high quality. If the product is inspected, then a certificate is issued stating that inspected products are of the highest quality, identical to that of homemade goods. In both periods 1 and 2, consumers do not need to experience the product to learn of its quality as the certificate is identifiable. For products that are not inspected, consumers learn of the quality through consumption and, in period 2 the qualities of all goods become known.[6]

Table 1 Firm F's Strategies and Market Structures

(a) Firm F Producing Low Quality

Inspection Probabilities	Period 1	Period 2
Inspection (μ)	No imports; domestic monopoly	No imports; domestic monopoly
No inspection $(1-\mu)$	Duopoly with differentiated products	No imports; domestic monopoly

(b) Firm F Producing High Quality

Inspection Probabilities	Period 1	Period 2
Inspection (μ)	Certification: duopoly with homogeneous products	Duopoly with homogeneous products
No inspection $(1-\mu)$	Duopoly with differentiated products	Duopoly with homogeneous products

[6] We abstract thus from cases where firm F may produce a mixture of low and high qualities to decrease the odds of detection. Also, with two qualities firm F may choose to produce high quality in period 1 and low quality in period 2. Experience leads then to misleading results in a finite time horizon, but not in an infinite horizon.

As Firm F has the choice between exporting high-quality or low-quality goods, its quality selection depends on the comparison of expected discounted profits. Normally, higher quality goods require higher costs to produce. This, along with the market structure, will affect the firm's profits. In panel (a) firm H is a monopolist in all cells except when goods are not inspected in period 1. The market structure is then a duopoly with differentiated goods since consumers differentiate goods by country of origin. In panel (b), the market structure is a duopoly with homogeneous goods in all cells except when goods are not inspected in period 1. As in panel (a), the market structure is then a duopoly with differentiated goods.

3. Consumer Demand

A typical Home consumer consumes a numeraire good *m*, and two differentiated goods *x* and *x**, respectively produced by firm H and firm F. Goods made at Home have the highest recognition in both brand name and quality while those made in F have low acceptance by home consumers and could be considered as having lower quality, due to problems of reputation, asymmetric information, etc. Given the above, the typical Home consumer can be assumed to maximize the following utility function:

$$V(m, x, x^*) = m + U(x, x^*) \qquad (1)$$

where

$$U(x, x^*) = x + \theta x^* - (x^2 + x^{*2})/2 - \gamma x x^* \qquad (2)$$

where $\gamma \in (0,1]$ indicates the degree of substitutability between goods x and x^* : the two goods become more substitutable as γ increases (We do not consider the case where goods are complements, i.e., when $\gamma < 0$). Similar demand specifications are frequently used in the literature, see e.g. Dixit (1988) and Bester and Petrakis (1993).

Parameter $\theta \in [0,1]$ represents home consumers' valuation of imports and bias against foreign production. With $\theta < 1$ the marginal utility that a home consumer derives from consuming the foreign good is lower than from home goods, reflecting the argument that consumers in rich countries discount imported goods from poor countries.[7] In practice it can represent product quality, food safety or brand recognition, etc. As for the relationship between γ and θ, we can think of the former as coming from the manufacturing process, which causes the two products to be different possibly in appearance, quality, taste, etc., but the latter as coming from consumers' perception of the products.

Denote by p and p^* the price for each firm's product. Maximization of consumers' problem in (1) subject to the standard budget constraint yields the inverse demand functions for goods x and x^* in units of good *m:*

$$p(x, x^*) = 1 - x - \gamma x^*, \tag{3a}$$

$$p^*(x, x^*) = \theta - x^* - \gamma x. \tag{3b}$$

The corresponding direct demand functions are:

$$x(p, p^*) = \frac{1-\theta\gamma}{1-\gamma^2} - \frac{p}{1-\gamma^2} + \frac{\gamma p^*}{1-\gamma^2}, \tag{3a'}$$

$$x^*(p, p^*) = \frac{\theta-\gamma}{1-\gamma^2} + \frac{\gamma p}{1-\gamma^2} - \frac{p^*}{1-\gamma^2}. \tag{3b'}$$

Equations (3a') and (3b') reproduce the properties known in the literature. For example, own-price effects are larger than cross-price effects. Also the market scale is higher for home goods than for foreign goods as long as $\theta < 1$.

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[7] The marginal rate of substitution between units of the same commodity, produced in different countries, is different from unity when $\theta < 1$: $dx^* / dx = -(1 - x - \gamma x^*) / (\theta - x^* - \gamma x)$.

4. Tainted Food

Since we focus on firm F's choices and on home government's design of incentives to improve import quality, let us assume that firm H always produces high quality using a production technology represented by the cost function *C(x)=cx*, with $c < 1$ to ensure positive demands. Home government levies a specific tariff t on imports from F. Home health authorities charge a fixed fee K^* to cover costs of inspection. The foreign firm has access to two technologies (indexed by i), one producing a low-quality variant l and the other producing high quality h. Marginal costs are given by c_l^* and c_h^*, and we require:

Assumption 1: $c_l^* \leq c_h^*$ *and* $c_h^* + t < c < 1$.

This assumption reflects technical requirements on quality control that drive up the cost of high quality relative to low-quality production. The marginal cost of tainted food production is assumed sufficiently low.

4.1 Market Structures

In equilibrium, different sets of prices will be charged depending on the quality choice made by firm F (i=l,h). As most goods we are considering are processed goods for which capacity constraints play a lesser role, we assume firms in the product market compete in price (Results would not change qualitatively if Cournot competition is assumed instead but derivations would become more involving.). Then, we can straightforwardly derive the equilibrium of the three market structures described in Table 1.

Domestic Monopoly

The domestic monopoly arises when local health authorities uncover tainted food. Likewise the situation arises when consumers experience the imported commodity as tainted.

Imports are then prohibited ($x_l^* = 0$) and firm H becomes the sole supplier, as under autarky. Given this information, domestic profits are $\pi_l = (1-c)^2 / 4$ in all relevant periods and, the time profile of foreign profits becomes:

$$\pi_l^* = -K^* \tag{4}$$

in the first period and zero otherwise.

Duopoly with Homogenous Goods

This is the case of three cells in Table 1 (b). When average costs are constant but not equal across firms, Bertrand competition yields an equilibrium in which the firm with the lowest marginal cost is the only one to produce positive output. The equilibrium price is then the limit price equal to (or slightly below) the marginal cost of the second most efficient firm:

$$p_h = \max\left\{c, c_h^* + t\right\} = c \tag{5}$$

It follows that domestic profits are driven down to zero and, foreign profits take the following values:

$$\pi_h^* = (1-c)(c - c_h^* - t) - K^* \tag{6}$$

in period 1 and $\pi_h^* = (1-c)(c - c_h^* - t)$ in other cells.

Duopoly with Differentiated Goods

A duopoly with differentiated goods arises in one cell of Table 1(a) and of Table 1(b), in period 1 and when imports are not inspected. Both firms make their supply decisions rationally. Each of them holds Bertrand conjecture about the decisions of the other producer. Profits of the two firms are respectively:

$$\pi(p_i, p_i^*) = (p_i - c)x(p_i, p_i^*), \qquad i = l,h \tag{7a}$$

$$\pi_i^*(p, p_i^*) = \left[p_i^* - (c_i^* + t) \right] x(p, p_i^*), \quad i = l,h \tag{7b}$$

The Nash-Bertrand equilibrium can be obtained as:

$$p_i = (\frac{1}{4-\gamma^2})\{(2-\gamma^2-\gamma\theta)+2c+\gamma(c_i^*+t)\}, \; i = l,h, \tag{8a}$$

$$p_i^* = (\frac{1}{4-\gamma^2})\{\theta(2-\gamma^2)-\gamma+\gamma c+2(c_i^*+t)\}, \; i = l,h, \tag{8b}$$

$$x_i = (\frac{1}{4-\gamma^2})(\frac{1}{1-\gamma^2})\{(2-\gamma^2)(1-c)-\gamma(\theta-c_i^*-t)\}, \; i = l,h, \tag{8c}$$

$$x_i^* = (\frac{1}{4-\gamma^2})(\frac{1}{1-\gamma^2})\{(2-\gamma^2)(\theta-c_i^*-t)-\gamma(1-c)\}, \; i = l,h, \tag{8d}$$

Using (8a) and (8c), the equilibrium profits of firm H are obtained as: $\pi_{1i} = (1-\gamma^2)x_i^2$ for i = l,h. Firm F's equilibrium profits are obtained from (8b) and (8d):

$$\pi_i^* = (1-\gamma^2)x_i^{*2}, \qquad i = l,h. \tag{9}$$

The market equilibrium obtained in (8c) and (8d) has a number of properties. For example, there exists a prohibitive tariff $\overline{t_i} = \left[\theta - c_i^* - \gamma(1-c)/(2-\gamma^2)\right]$ that shuts down imports. Also $x_i^* > x_i$ when $c - c_i^* - t > 1-\theta$, i.e., when the difference in marginal costs is less than offset by the difference in market scales. In addition, Assumption 1 implies $x_l^* \geq x_h^*$ and from (9) it follows that $\pi_l^* > \pi_h^*$, which makes this market equilibrium particularly interesting.

The above discussion is summarized in Table 2 in terms of foreign production and foreign profits. For the sake of clarity we introduce a first subscript to denote time, a second to represent quality as before, and superscript 'I' to indicate when imports are inspected.

4.2 Firm F's Quality Choice

As mentioned earlier, firm F's decisions are made at the outset of period 1, but affect the profits of two periods. Then the expected profits of low-quality production over two periods are given by:

$$\Pi_l^* = \mu(\pi_{1l}^*)^I + \mu\delta(\pi_{2l}^*)^I + (1-\mu)\pi_{1l}^* + (1-\mu)\delta\pi_{2l}^*$$

where δ denotes the private discount factor common to all agents. Making use of Table 2(a):

$$\Pi_l^* = -\mu K^* + (1-\mu)(1-\gamma^2)x_{1l}^{*2} \tag{10}$$

On the other hand, expected profits of high-quality production over two periods:

$$\Pi_h^* = \mu(\pi_{1h}^*)^I + \mu\delta(\pi_{2h}^*)^I + (1-\mu)\pi_{1h}^* + (1-\mu)\delta\pi_{2h}^*$$

Making use of Table 2(b) gives:

$$\Pi_h^* = (\mu+\delta)\left[(1-c)(c-c_h^*-t)\right] - \mu K^* + (1-\mu)(1-\gamma^2)x_{1h}^{*2} \tag{11}$$

Table 2 Foreign Firm's Profits

(a) Low-quality

Inspection Probabilities	Period 1	Period 2
Inspection μ	$(x_{1l}^*)^I = 0$ $(\pi_{1l}^*)^I = -K^*$	$(x_{2l}^*)^I = 0$ $(\pi_{2l}^*)^I = 0$
No inspection $(1-\mu)$	$x_{1l}^* = (\frac{1}{4-\gamma^2})(\frac{1}{1-\gamma^2})\{(2-\gamma^2)(\theta-c_l^*-t)-\gamma(1-c)\}$ $\pi_{1l}^* = (1-\gamma^2)x_{1l}^{*2}$	$x_{2l}^* = 0$ $\pi_{2l}^* = 0$

(b) High-quality

Inspection Probabilities	Period 1	Period 2
Inspection μ	$(x^*_{1h})^I = 1-c$ $(\pi^*_{1h})^I = (1-c)(c-c^*_h-t)-K^*$	$(x^*_{2h})^I = 1-c$ $(\pi^*_{2h})^I = (1-c)(c-c^*_h-t)$
No inspection $(1-\mu)$	$x^*_{1h} = (\frac{1}{4-\gamma^2})(\frac{1}{1-\gamma^2})\{(2-\gamma^2)(\theta-c^*_h-t)-\gamma(1-c)\}$ $\pi^*_{1h} = (1-\gamma^2)x^{*2}_{1h}$	$x^*_{2h} = 1-c$ $\pi^*_{2h} = (1-c)(c-c^*_h-t)$

Therefore at the outset of period 1 firm F faces the following binary decision problem: $Max\ (\Pi^*_l, \Pi^*_h)$; that is, choosing the optimal quality strategy by maximizing the expected net present value of profits. Using (10) and (11) we can establish the following proposition:

Proposition 1 (Tainted food): *Tainted food is produced and exported by the foreign firm when the following condition is fulfilled:*

$$\frac{(1-\mu)(2-\gamma^2)^2(c^*_h-c^*_l)}{(4-\gamma^2)^2(1-\gamma^2)}\left\{(2\theta-c^*_h-c^*_l-2t)-\frac{2\gamma(1-c)}{(2-\gamma)}\right\} > (\mu+\delta)(1-c)(c-c^*_h-t) \quad (12)$$

Proof: The difference in expected profits between low- and high-quality productions is obtained by taking the difference between (10) and (11):

$$\Pi^*_l - \Pi^*_h = -(\mu+\delta)[(1-c)(c-c^*_h-t)] + (1-\mu)(1-\gamma^2)(x^{*2}_{1l} - x^{*2}_{1h}) \quad (13)$$

Making use of (8d) to substitute for x^*_{1l} and x^*_{1h}:

$$\Pi^*_l - \Pi^*_h = -(\mu+\delta)[(1-c)(c-c^*_h-t)]$$
$$+\frac{(1-\mu)}{(1-\gamma^2)}\frac{(2-\gamma^2)^2}{(4-\gamma^2)^2}(c^*_h-c^*_l)\left\{(2\theta-c^*_h-c^*_l-2t)-\frac{2\gamma}{(2-\gamma)}(1-c)\right\} \quad (13')$$

which is positive when condition (12) is met. ■

Condition (12) compares the single-period profits of low-quality production with the multi-period profits of high-quality production. As formulated above, the first term represents the positive difference in profits between low- and high-quality production under product differentiation whereas the second term represents profits from high-quality production under limit pricing. As this condition depends on all primitive parameters of the model, namely the marginal costs, parameters $\gamma, \theta, \delta, \mu$, and the import tariff *t*, we derive the monotonicity results of (12) in Table 3, from which we obtain:

Proposition 2: *The incentives to produce tainted products are decreased if the inspection rate* μ*, the discount rate* δ *or the cost of producing low-quality* c_l^* *rises. On the other hand, an increase in the foreign firm's scale parameter* θ *or the marginal cost of home production c raises the foreign firm's incentives to produce tainted products.*

Proof: see Table 3.

Table 3 Monotonicity Results of Equation (12)

	μ	δ	c_h^*	c_l^*	c	θ	t
$\Pi_l^* - \Pi_h^*$	-	-	?	-	+	+	?

Note that expression (12) is never met and tainted products are never produced when $c_h^* = c_l^*$. The intuition is that high-quality production is never out of reach for firms in the foreign country, simply because compliance costs that must be incurred to meet the sanitary standards imposed by the H government are low. These producers prefer then to make and export high-quality products. However, increasing c_h^* has a non-linear effect on the profit differential but the sign cannot be determined *a priori* (though expected to be positive).

A striking implication of this framework is the effect of the specific tariff *t*. To that end let us focus on $(\Pi_h^* - \Pi_l^*)$ instead and making use of (13') we obtain:

$$\frac{\partial(\Pi_h^* - \Pi_l^*)}{\partial t} = -\frac{\partial(\Pi_l^* - \Pi_h^*)}{\partial t} = -(\mu + \delta)(1-c) + \frac{2(1-\mu)(2-\gamma^2)^2}{(1-\gamma^2)(4-\gamma^2)^2}(c_h^* - c_l^*) \quad (14)$$

Expression (14) can be either positive or negative. The first term represents the loss in profits from high quality when limit pricing is applied whereas the second term measures the net gain in profits under product differentiation. We thus have the following result, noting that freer trade in our framework means a decrease in *t*:

Proposition 3 (Free trade): *Free trade is the trading system that gives the highest incentives to foreign exporters to produce non-tainted high-quality goods when:*

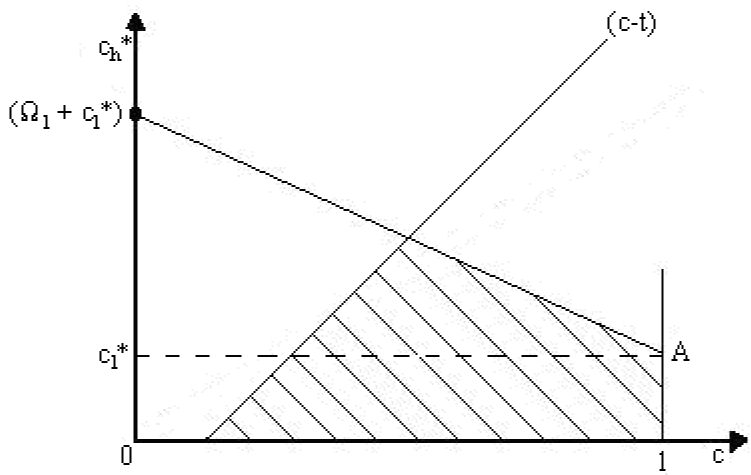
$$(\mu + \delta)(1-c) > \frac{2(1-\mu)(2-\gamma^2)^2}{(1-\gamma^2)(4-\gamma^2)^2}(c_h^* - c_l^*)\,. \quad (15)$$

However, free trade is neither a necessary nor a sufficient condition to exclude trade in tainted products.

Condition (15) describes the parameter space under which free trade is the optimal trading system. It is fulfilled when $c_h^* = c_l^*$ but may fail to hold with $c_h^* \gg c_l^*$. This shows that the free trading system can been undermined by national governments which in practice introduce nontraditional impediments to trade such as health, technical and sanitary standards whose compliance imposes additional costs on exporters from developing countries.

Figure 1 gives a graphical representation of (15) for a given c_l^*. In the grid of Figure 1 values for c and c_h^* are allowed to vary between 0 and 1 but are also constrained by the two inequalities of Assumption 1, depicted here by lines $c_h^* < (c-t)$ and $c < 1$. The downward sloping line is the solution of c_h^* in terms of c such that condition (15) is satisfied. Every combination below this line indicates when the inequality sign holds strictly. The shaded area gives therefore all combinations of c_h^* and c under which free trade is the trade policy of choice that excludes tainting. That free trade can be optimal runs counter to the popular claim put forward by some government officials and consumer organizations that unconditionally favor increased protectionism as a means to prevent tainted imports.

Figure 1 Tainting and Free Trade



Notes: (a) The shaded area gives all pairs (c_h^*, c) such that free trade is optimal; (b) $\Omega_1 = (\mu+\delta)(1-\gamma^2)(4-\gamma^2)^2 / 2(1-\mu)(2-\gamma^2) > 0$.

5. Type I and Type II Errors of Testing

So far we have assumed that inspection is perfect so that all low-quality, tainted goods are found and banned from entering country H. However, as plenty of evidence shows,[8] errors of testing arise frequently when inspectors fail to find fault with tainted goods, and by mistake, label them as high-quality goods. We investigate this situation here.

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[8] The New York Times (March 6, 2009) cites many examples in "Food Safety Problems Elude Private Inspectors". For instance, the American Institute of Baking which after performing audits at Peanut Corp. America, reported that "the overall food safety level of this facility was considered to be superior." Federal investigators later discovered salmonella.

Let us assume that the null hypothesis (H_0) is the presumption of innocence, meaning the absence of tainting in foreign exports. Given this, Table 4 describes the two possible errors that are made in testing procedures. A Type I error (α) is highly undesirable from the foreign exporter's standpoint. With probability α, the foreign high-quality good is by mistake found of being tainted. The effect of the Type I error is that his exports are denied entry into the domestic market and his reputation is tarnished. A Type II error (β) is a tragedy from the domestic society's standpoint. With probability β, foreign tainted goods are by mistake not detected. As a consequence, a certificate of high quality is issued to the exporter and consumers' health is in jeopardy.

Table 4 Errors of Testing

	High-quality production	Low-quality production
Reject H_0	Type I error (α): false positive	Correct
Fail to reject H_0	Correct	Type II error (β): false negative

Errors of testing affect the likelihood of different market outcomes but only occur when inspection is first performed. Table 5 reproduces part of Table 2 but corrects inspection probabilities for testing errors. The effect of Type I error α is that though high-quality products are made they are considered as tainted and therefore excluded from the market. As the reputation of the exporter is also ruined, we obtain new entries in panel (a) of Table 5:

$$(x^*_{1h})^I = 0,\ (\pi^*_{1h})^I = -K^*,\ (x^*_{2h})^I = 0,\ (\pi^*_{2h})^I = 0.$$

Expected profits of high-quality production can be computed as:

$$\Pi_h^* = (\mu + \delta - \mu\alpha(1+\delta))\left[(1-c)(c - c_h^* - t)\right] - \mu K^* + (1-\mu)(1-\gamma^2)x_{1h}^{*2}. \qquad (16)$$

Compared to (11) a new negative term linked to Type I error α enters (16). A Type I error harms the foreign exporter because its exports that were previously sold at the high -quality price are now prohibited after inspection. The beneficiary of the Type I error is the domestic firm since with probability α it becomes a monopolist in all periods.

Table 5 Testing Errors and Foreign Firm's Profits

(a) Low-quality

Inspection Probabilities	Period 1	Period 2
Inspection $\mu(1-\beta)$	$(x_{1l}^*)^I = 0$ $(\pi_{1l}^*)^I = -K^*$	$(x_{2l}^*)^I = 0$ $(\pi_{2l}^*)^I = 0$
Inspection $\mu\alpha$	$(x_{1h}^*)^I = 0$ $(\pi_{1h}^*)^I = -K^*$	$(x_{2h}^*)^I = 0$ $(\pi_{2h}^*)^I = 0$

(b) High-quality

Inspection Probabilities	Period 1	Period 2
Inspection $\mu(1-\alpha)$	$(x_{1h}^*)^I = 1-c$ $(\pi_{1h}^*)^I = (1-c)(c-c_h^*-t) - K^*$	$(x_{2h}^*)^I = 1-c$ $(\pi_{2h}^*)^I = (1-c)(c-c_h^*-t)$
Inspection $\mu\beta$	$(x_{1l}^*)^I = 1-c$ $(\pi_{1l}^*)^I = (1-c)(c-c_l^*-t) - K^*$	$(x_{2l}^*)^I = 0$ $(\pi_{2l}^*)^I = 0$

The effect of a Type II error is more consequential. It follows that in the first period low-quality foreign imports are labeled as high-quality and compete with homemade goods so we have a homogenous duopoly where the limit pricing rule applies. However, in the second period, consumers having experienced tainted imports refuse to buy them anymore. The domestic firm becomes thus a monopolist in period 2. The situation is described by the following entries in panel (b) of Table 5:

$$(x_{1l}^*)^I = 1-c\,,\ (\pi_{1l}^*)^I = (1-c)(c-c_l^*-t)-K^*\,,\ (x_{2l}^*)^I = 0\,,\ (\pi_{2l}^*)^I = 0\,.$$

Note that in Table 5 (a), with probability $\mu\alpha$, firm F is making high-quality goods that have erroneously been found to be tainted. Thus it is sold as low quality and enters the expression for low quality profits. And in Table 5(b), with probability $\mu\beta$, it is making low-quality goods that have been erroneously labeled high-quality goods; thus it is sold as high quality and enters the expression for profits of high-quality production.

As indicated earlier, firm F's decisions are made at the outset of period 1, but affect the profits of two periods. Repeating the steps of the preceding section, expected profits under low-quality production can be computed on the basis of Tables 2 and 5:

$$\Pi_l^* = -\mu K^* + \mu\beta(1-c)(c-c_l^*-t) + (1-\mu)(1-\gamma^2)x_{1l}^{*2}\,. \qquad (17)$$

Compared to (10), a new term that reflects the Type II error enters positively in (17): a Type II error benefits the foreign exporter when he produces low-cost tainted food because with probability β its tainted goods are now allowed to sell at the high-quality price. With $\alpha = \beta = 0$, (16) and (17) reduce to (11) and (10) respectively, and using them, the difference in expected profits between low- and high-quality productions becomes:

$$\begin{aligned}\Pi_l^* - \Pi_h^* = &-(\mu+\delta-\mu\alpha(1+\delta))[(1-c)(c-c_h^*-t)] + \mu\beta\left[(1-c)(c-c_l^*-t)\right] \\ &+\frac{(1-\mu)}{(1-\gamma^2)}\frac{(2-\gamma^2)^2}{(4-\gamma^2)^2}(c_h^*-c_l^*)\left\{(2\theta-c_h^*-c_l^*-2t)-\frac{2\gamma}{(2-\gamma)}(1-c)\right\}\end{aligned} \qquad (18)$$

From (18) and the above discussion we can establish the following proposition:

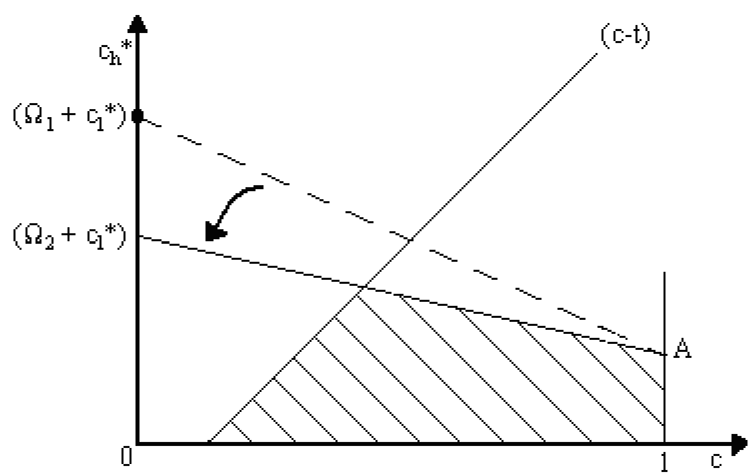
Proposition 4 (Type I and Type II errors): *Type I errors (α) and Type II errors (β) of testing increase profits and incentives to produce and export tainted products.*

It is clear from (18) that testing errors also change how the specific tariff affects the profit differential:

$$\frac{\partial(\Pi_h^* - \Pi_l^*)}{\partial t} = -\left[\mu + \delta - \mu\alpha(1+\delta) - \mu\beta\right](1-c) + \frac{2(1-\mu)(2-\gamma^2)^2}{(1-\gamma^2)(4-\gamma^2)^2}(c_h^* - c_l^*) \qquad (19)$$

which reduces to (14) when $\alpha = \beta = 0$ but is larger otherwise. Depending on the values of α and β, (19) can turn negative. As a result the shaded area that gives all combinations of c_h^* and c such that free trade is the prevailing policy is smaller in Figure 2 than in Figure 1. Therefore, testing errors undermine the free trading system as a devise to provide incentives to produce and trade high-quality products.

Figure 2 Testing Errors and Free Trade



Notes: (a) The shaded area gives all pairs (c_h^*, c) such that free trade is optimal;
(b) $\Omega_2 = (\mu(1-\alpha(1+\delta)-\beta)+\delta)(1-\gamma^2)(4-\gamma^2)^2 \,/\, 2(1-\mu)(2-\gamma^2) > 0$ with $\Omega_2 < \Omega_1$.

6. The Role of Investments

So far it has been assumed that $\theta(\leq 1)$ is exogenous. However, foreign firms can undertake investments to enhance consumers' perception of their products. Their objective is to affect consumers' preference which usually favor domestically made products over imported goods, especially when they come from developing countries and when it concerns food products. Investments could be done via advertising campaigns and trade fairs. Hence, θ becomes endogenous and an 'optimal' θ can be obtained in our model by introducing profit-maximizing investments.[9]

A duopoly with differentiated goods arises in one cell of Table 1(a) and of Table 1(b), in period 1 and when imports are not inspected. With investment the market is assumed to evolve in two stages, decisions made in the first stage being fully observable in the second stage. First, firm F decides unilaterally on how much to invest in the enhancement of the perception of its product. Second, both firms make their supply decisions rationally. We assume Bertrand conjecture and solve the model by backward induction as before.[10]

As the solution obtained in (8a)-(8b) and (9) describes the market equilibrium of the second stage it suffices to focus on the determination of investments in the first stage. With investments, profits of the two firms in the second stage of the game are respectively:

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[9] There are however some constraints. For example, when investing the foreign firm does not want to reveal its quality choice to consumers. Also investments are only optimal under differentiated products since in other market structures, imports are either prohibited or experienced and certified, which make investments redundant.

[10] The domestic firm that enjoys the reputation of a high-quality producer has no incentive to invest in image building. However, it may counteract firm F's attempt to upgrade its market scale by undertaking investments to damage firm F's product image. The market would evolve then in two stages, with firms F and H deciding simultaneously on how much to invest. Here in order to focus on F's investment, we ignore this possibility with the following assumption: $c - c_i^* - t > 1 - \theta$. Then foreign imports are larger than domestic production ($x_i^* > x_i$) because the difference in marginal costs is less than offset by the difference in market scales. Also $(1-\gamma^2)x_i^{*2} > (1-\gamma^2)x_i^2$; that is, firm F's operational profits are larger than those of firm H, and firm F is able to outcompete firm H in an investment game if the latter decides to make investments to lower firm F's product image. As a result, firm H which has also other more rewarding disrupting activities (see next section) does not participate, and firm F then becomes the sole investor.

$$\pi_i = (1-\gamma^2)x_i^2, \quad i = l,h \tag{20a}$$

$$\pi_i^* = (1-\gamma^2)x_i^{*2} - f^*, \quad i = l,h \tag{20b}$$

where f^* denotes first-stage investment which is common to both qualities and where outputs x_i and x_i^* are given by (8c) and (8d). In the first stage, firm F tries to improve home consumers' perception of its product. In particular, it invests in order to increase its market scale variable θ by using the following linear technology:

$$\theta = \omega + \lambda f^* \tag{21}$$

As firm F does not want to reveal its product quality, it chooses a single level of investment across product qualities. Thus we assume that it does so by maximizing the sum of first-period profits ($\pi_l^* + \pi_h^*$). Using (21) in x_i^*, profit maximization with respect to f^* gives:

$$\frac{\partial(\pi_l^* + \pi_h^*)}{\partial f^*} = 2\frac{\lambda(2-\gamma^2)}{(4-\gamma^2)}(x_l^* + x_h^*) - 2 = 0$$

Together with (8c) and (8d), this first order condition yields:

$$\theta = \frac{(4-\gamma^2)^2(1-\gamma^2)\lambda}{2(2-\gamma^2)^2} + \frac{\gamma(1-c)}{(2-\gamma^2)} + \frac{(c_l^* + c_h^*)}{2} + t, \tag{22a}$$

$$f^* = \frac{\theta}{\lambda} - \frac{\omega}{\lambda}, \tag{22b}$$

The optimal level of investment is chosen such that outputs across qualities satisfy:

$$(x_l^* + x_h^*) = \frac{(4-\gamma^2)}{\lambda(2-\gamma^2)} \tag{23a}$$

$$(x_l^* - x_h^*) = \frac{(2-\gamma^2)}{(4-\gamma^2)(1-\gamma^2)}(c_h^* - c_l^*) \tag{23b}$$

$$\pi_l^* - \pi_h^* = (1-\gamma^2)x_l^{*2} - f^* - (1-\gamma^2)x_h^{*2} + f^* = \frac{(c_h^* - c_l^*)}{\lambda} \tag{24}$$

Given this information firm F's quality choice is readily obtained. Repeating the steps of Section 4 expected profits of low-quality production can be obtained as:

$$\Pi_l^* = -\mu K^* + (1-\mu)(1-\gamma^2)x_{1l}^{*2} - (1-\mu)\,f_1^*$$

On the other hand, expected profits of high-quality production are:

$$\Pi_h^* = (\mu+\delta)\Big[(1-c)(c-c_h^*-t)\Big] - \mu K^* + (1-\mu)(1-\gamma^2)x_{1h}^{*2} - (1-\mu)\,f_1^*$$

Making use of (24), the difference in expected profits between high- and low-quality productions becomes:

$$\Pi_l^* - \Pi_h^* = -(\mu+\delta)[(1-c)(c-c_h^*-t)] + \frac{(1-\mu)}{\lambda}(c_h^* - c_l^*) \tag{25}$$

Using (25) we can establish the following proposition:

Proposition 5 (Investment and tainted food): *When it is optimal for the foreign firm to invest resources in image building and when the following condition is fulfilled:*

$$\frac{(1-\mu)}{\lambda}(c_h^* - c_l^*) > (\mu+\delta)(1-c)(c-c_h^*-t)\,, \tag{26}$$

the foreign firm will produce and export tainted food.

The incentives to produce low quality in (26) can be compared with those in (12). The former is satisfied when $c_h^* \gg c_l^*$. The intuition is that high-quality production is out of reach for some firms in the foreign country, due to, say, too high compliance costs that must be incurred to meet the high sanitary standards imposed by the H government. These firms then decide to skimp on quality and export tainted products. This is possible as long as local health authorities are only able to check a very small fraction of total shipments.

Another implication of this scenario is the clear cut effect of the specific tariff *t*. From (25) it is immediate that:

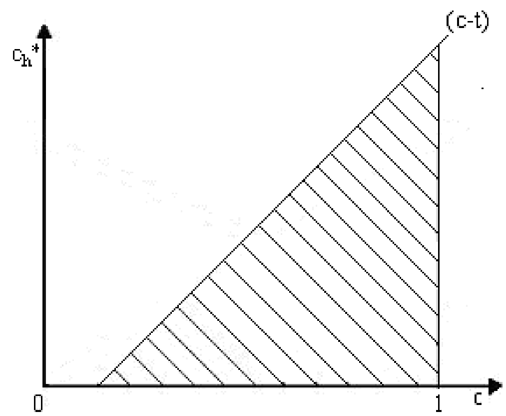
$$\frac{\partial(\Pi_h^* - \Pi_l^*)}{\partial t} = -\frac{\partial(\Pi_l^* - \Pi_h^*)}{\partial t} = -(\mu+\delta)(1-c) < 0 \qquad (27)$$

Unambiguously, an increase in *t* causes, *ceteris paribus*, a decrease (increase) in the incentives to produce high-quality goods (tainted products). As a result the shaded area of Figure 3 that gives all parameter combinations that support free trade is enlarged and includes all feasible parameter combinations. We thus have the following result:

Proposition 6 (Investment and free trade): *When the foreign firm invest resources to improve consumers' perception of its product, free trade is the trading system that provides the highest incentives to foreign exporters to produce non-tainted high-quality goods.*

Again, this result runs counter to the popular claim put forward by some government officials and consumer organizations that favor increased protectionism as a means to prevent tainted imports. Together with Proposition 3, it shows freer trade is necessary to induce high-quality non-tainted imports, when governments in practice cannot raise the rate of import inspection due to various constraints such as those on budget, personnel, or technology.

Figure 3 Investment and Free Trade



Note: The shaded area gives all pairs (c_h^*, c) such that free trade is optimal.

7. Sabotage

Foreign firm's export success is very often subject to countermeasures by the domestic firm which does not want the market for its products to fade away. Possible reactions are sabotage activities by domestic competitors. The term 'sabotage' usually refers to countermeasures in market contests that are almost unobservable and sometimes illegal. The idea that stems from Veblen (1923) in the context of business competition and market power has since been considered in several fields: for example, Baumol (1992) on innovation, Salop and Scheffman (1987) and Roy and Viaene (1998) on strategies to raise rivals' cost, Lazear (1989) on contests within firms and Konrad (2000) in the context of lobbying efforts for policy favors. Sabotage activities take at least two forms. One is damaging the rival's image, and the other is increasing the rival's costs. Since we have shown in the preceding section that the former is dominated by improving a firm's own image (see footnote 10), we shall focus on the latter.[11]

Raising rival's cost is effective for firm H, simply because some of the market equilibria of Table 1(b) might reverse in its favor. Denoting sabotage activities by *s*, marginal costs can be expressed as $c_i^*(s)$ with $\partial c_i^*(s) / \partial s > 0$. We obtain straightforwardly:

Proposition 7 (Sabotage): *Sabotage by the domestic firm aimed at raising the foreign firm's marginal cost of production: (i) decreases the likelihood of tainting if the marginal cost of low quality is increased; (ii) causes tainting if the marginal cost of high quality is increased.*

Proof: Sabotage of low-quality production affects only one cell of Table 2(a): when the imported good is not checked, for which consumers have to gain experience. In this case only (13) is affected. With $c_l^*(s)$ increasing in *s*, sabotage reduces both x_l^{*2} and the right hand side of (13). The likelihood of tainting decreases which proves part (i). To prove part (ii) note that sabotage of high-quality production affects all market equilibria of Table 2(b). With sufficient sabotage activity, the limit pricing condition (5) reverses to:

$$p_h = \max\left\{c, c_h^*(s) + t\right\} = c_h^*(s) + t \tag{5'}$$

Foreign profits in Table 2(b) then become:

$$(\pi_{1h}^*)^I = -K^*,\ (\pi_{2h}^*)^I = \pi_{2h}^* = 0$$

In turn, domestic profits take the following values:

$$(\pi_{1h})^I = (\pi_{2h})^I = \pi_{2h} = \left[1 - (c_h^*(s) + t)\right]\left[c_h^*(s) + t - c\right] \tag{6'}$$

[11] Examples include business interruptions caused by strikes, punctured packaged products, sabotage in counterfeit hardware, sabotage of networks, etc. Bailed out American International Group advertises insurances that are designed to cover these specific risks (see the AIG Web site).

Using (6’), the participation constraint of the domestic firm in sabotage activities is:

$$(\mu+\delta)\left[1-(c_h^*(s)+t)\right]\left[c_h^*(s)+t-c\right]>s$$

Turning now to expected profits, while (10) remains unchanged, (11) becomes:

$$\Pi_h^* = -\mu K^* + (1-\mu)(1-\gamma^2)x_{1h}^{*2} \qquad (11')$$

The difference in expected discounted profits between low- and high-quality productions is obtained by taking the difference between (10) and (11’):

$$\Pi_l^* - \Pi_h^* = (1-\mu)(1-\gamma^2)(x_{1l}^{*2} - x_{1h}^{*2}) > 0,$$

that is always positive. Thus tainting in this case is caused by sabotage of high-quality production by the domestic firm. ■

This proposition has important implications. First note that sabotage of low-quality tainted imports affects profits in the first period when imports are not checked whereas sabotage of high quality affects multi-period profits under all inspection status. The dominant strategy of firm H is therefore to affect firm F‘s marginal cost of *high* quality. Firm F taking this into account will produce the low-quality variant, even worse, the incentives to produce tainted goods increase. This will allow the domestic firm to enjoy a monopoly position as described in Table 1. Home consumers have the most to lose as a consequence, since sabotage increases both foreign tainting and the home firm’s market power.

In addition, we can characterize the cost-minimizing level of sabotage activity. Let $\bar{s}$ denote the level of sabotage such that average costs are just equal across firms. Any sabotage activity slightly above $\bar{s}$ allows the domestic firm to be more efficient. From the limit price condition (5) it follows that the limit price is: $p_h = c = c_h^*(\bar{s}) + t$. Solving for $\bar{s}$ we obtain $\bar{s} = c_h^{*-1}(c-t)$ with $\partial\bar{s}/\partial t < 0$. Hence we straightforwardly have the following result:

Proposition 8 (Sabotage and Free trade): *Free trade increases the cost incurred by the domestic firm to sabotage foreign production of high quality, which consequently lowers tainting.*

8. Welfare

Whatever the choice of firm F, aggregate welfare of the home country is important. The H government can increase inspection μ by spending more resources, and/or use tariffs to maximize welfare across firm F's choices. However, the measurement of welfare is a complex issue with experience goods. The *ex ante* consumer surplus derived from consumption choices differs from unknown *ex post* consumer surplus because the latter includes the disutility generated by first-period consumption of eventually tainted goods. If consumption of tainted food leads to diseases or death, the disutility is so overwhelming that the aggregate welfare may become negative. On the other hand, more often less extreme situations exist. Defective products for example do not put public health in danger and their consumption is justified if prices are sufficiently low. Also the tariff has two opposing effects. It raises both the consumer price and the tariff revenue. Thus the source of gain for the H government resides in the optimal capture of the foreign exporter's surplus.

Domestic welfare is defined as the arithmetic sum of the consumer surplus (CS_i), the home firm's profits (π_i) and the tariff revenues (R_i): $W_i = CS_i + \pi_i + R_i$. With consumers' utility being specified in (1) and (2), we can write the consumer surplus as the net utility derived from the consumption of x_i and x_i^*:

$$CS_i = (1-p_i)x_i + (\theta - p_i^*)x_i^* - (x_i^2 + x_i^{*2})/2 - \gamma x_i x_i^*, \quad i = l,h \tag{28}$$

It is then clear that an increase in prices reduces the consumption of the numeraire good and thus utility. Table 6 reproduces the components of welfare across periods and inspection status. The cells are obtained using preceding derivations, and we emphasize that the *ex ante* measure of consumer surplus is used. The expected utility under quality i is given by:

$$\psi_i = \mu(W_{1i})^I + \mu\delta(W_{2i})^I + (1-\mu)W_{1i} + (1-\mu)\delta W_{2i}, \quad i = l,h$$

where δ denotes the private discount factor common to all agents. Using Table 6 yields:

$$\psi_l = \frac{3}{8}(\mu+\delta)(1-c)^2 + (1-\mu)\left[CS_{1l} + (1-\gamma^2)x_{1l}^2 + tx_{1l}^*\right], \tag{29a}$$

$$\psi_h = (\mu+\delta)\left[\frac{(1-c)^2}{2} + t(1-c)\right] + (1-\mu)\left[CS_{1h} + (1-\gamma^2)x_{1h}^2 + tx_{1h}^*\right], \tag{29b}$$

which gives the expected present value of welfare difference between high- and low-quality:

$$\begin{aligned}\psi_h - \psi_l = (\mu+\delta)(1-c)\left[\frac{(1-c)}{8} + t\right] + \\ (1-\mu)\left[(CS_{1h} - CS_{1l}) + (1-\gamma^2)(x_{1h}^2 - x_{1l}^2) + t(x_{1h}^* - x_{1l}^*)\right]\end{aligned} \tag{30}$$

Table 6 Components of Domestic Welfare

(a) Firm F Produces Low Quality

Inspection probabilities	Period 1	Period 2
Inspection μ	$(CS_{1l})^I = (1-c)^2/8$ $(\pi_{1l})^I = (1-c)^2/4$ $(R_{1l})^I = 0$	$(CS_{2l})^I = (1-c)^2/8$ $(\pi_{2l})^I = (1-c)^2/4$ $(R_{2l})^I = 0$

No inspection $(1-\mu)$	$CS_{1l} = (1-p_{1l})x_{1l} + (\theta - p_{1l}^*)x_{1l}^* - (x_{1l}^2 + x_{1l}^{*2})/2 - \gamma x_{1l}x_{1l}^*$ $\pi_{1l} = (1-\gamma^2)x_{1l}^2$ $R_{1l} = tx_{1l}^*$	$CS_{2l} = (1-c)^2/8$ $\pi_{2l} = (1-c)^2/4$ $R_{2l} = 0$

(b) Firm F Produces High Quality

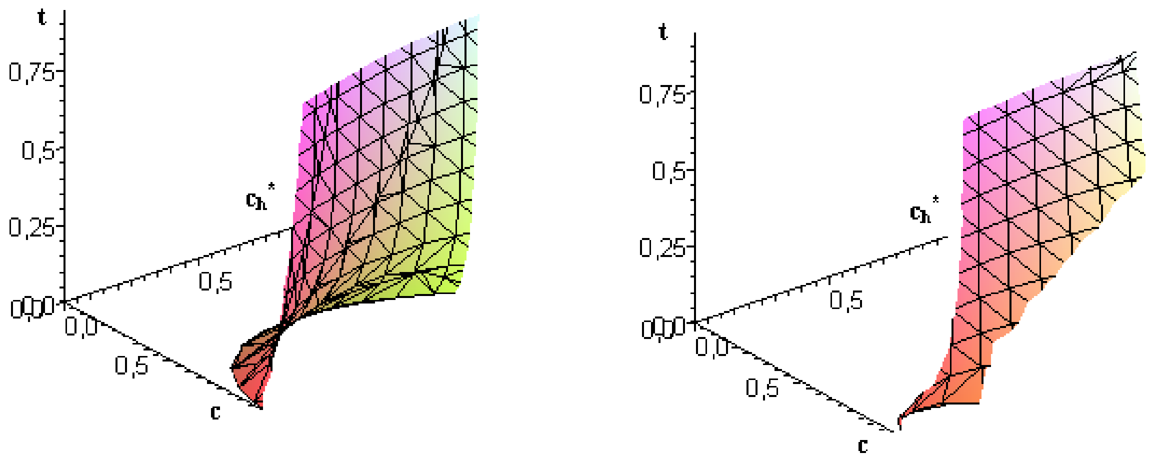
Inspection probabilities	Period 1	Period 2
Inspection μ	$(CS_{1h})^I = (1-c)^2/2$ $(\pi_{1h})^I = 0$ $(R_{1l})^I = t(1-c)$	$(CS_{2h})^I = (1-c)^2/2$ $(\pi_{2h})^I = 0$ $(R_{2h})^I = t(1-c)$
No inspection $(1-\mu)$	$CS_{1h} = (1-p_{1h})x_{1h} + (\theta - p_{1h}^*)x_{1h}^* - (x_{1h}^2 + x_{1h}^{*2})/2 - \gamma x_{1h}x_{1h}^*$ $\pi_{1h} = (1-\gamma^2)x_{1h}^2$ $R_{1h} = tx_{1h}^*$	$CS_{2h} = (1-c)^2/2$ $\pi_{2h} = 0$ $R_{2h} = t(1-c)$

The first term is positive, since the market for high-quality products is more competitive. The contribution of the second term is unknown under general conditions because the difference in consumer surpluses cannot be signed analytically.[12]

[12] When optimal, investments in image building connect θ's across quality types. This eases the comparison of consumer surpluses, and thus the analytical difficulty disappears.

Figure 4 Ex ante Welfare and Low-Quality Products

(a) (b)



Notes: (i) Assumed parameter values: $\mu = 0.11$; $\delta = 1/(1.05)$; $\gamma = 0.5$; $c_l^* = 0$;
(ii) $\theta = 0.7$ for panel (a) while $\theta = 0.1$ for panel (b).

Given this, we perform numerical simulations to give an interpretation to (30). Figure 2 reproduces these in a three- dimensional graph combining *t*, *c* and c_h^*, based on a grid between 0 and 1 and where parameter drawings are constrained by Assumption 1. The graphs illustrate the difference in present-value welfare between high- and low-quality production. We use $\theta = 0.7$ in panel (a) and $\theta = 0.1$ in panel (b). In each panel the plane represents the threshold $\psi_h - \psi_l = 0$. The area below or to the right of the plane is indicative of a welfare of low quality that exceeds that of high quality ((30) is negative); *vice versa* for the area to the left of the planes. An important conclusion to draw from Figure 2 is that the set of parameters under which low quality is preferred to high quality is not empty. A lower θ like in panel (b) reduces *ceteris paribus* the area under this plane. Likewise the area under the plane (see (30)) becomes bigger when μ or δ increases.

9. Concluding Remarks

This paper considered international trade in tainted food and examined various designs of incentive schemes for exporting firms produce non-tainted, high-quality products. The issue arises because many governments and consumer organizations relying on food imports have repeatedly put forward the view that the process of further globalization should be halted. Central to the issue, is the popular conjecture that the global food crisis calls for more restrictions on international trade in order to prevent imports of tainted food. However, a main result of this paper shows the opposite: for a large class of environments, free trade is the trading system that provides the highest incentives to foreign exporters to produce non-tainted high-quality goods. This is reinforced when the foreign firm undertakes image building investments. Moreover, imposing a tariff may decrease the cost of sabotage activities by the domestic firm, further increasing the foreign firm's incentives to produce low quality and raising the domestic firm's market power. As a consequence, home consumers lose as they pay higher prices due to more market concentration.

The setup of this paper could be extended in a number of ways. For example, so far we have assumed that a good is not imported once inspected by authorities. It is possible to allow imports of such goods as long as they are not poisonous, and label goods as 'low quality' by authorities. The model becomes then a model with two different types of qualities (but no tainting). The assumption of certification could also be relaxed. With certification, there is no reason for consumers to discount imports. Authorities certify that foreign goods are of the same grade as home goods. This was the scenario envisaged in Table 1(b). However, an inefficient firm H has incentives to lobby the government against the act of certification simply because in its absence, consumers keep on discounting foreign goods and product differentiation is maintained. Most qualitative results of the paper are not altered in this new setting. In addition, many industrial countries rely on imports for most of the food they consume.[13] Hence, relying on a single home producer as indicated in Table 1 might not be feasible once tainted food is uncovered (by inspection or by experience), simply because the home monopolist does not produce enough in calorie terms. Finding a substitute for firm F is possible if the model considers more foreign firms. This would not change results as long as Assumption 1 is maintained, i.e., as long as the firm with the lowest marginal cost is an exporting firm. Bertrand competition then yields market equilibria that are similar to those described in the paper. Though domestic welfare will differ, incentives to the foreign firm are not altered, and most propositions still remain robust. Further, the H-government could impose tariffs on first-period imports only, and let imports come in free in the second period. This then rewards high quality exports in the second period and home welfare might be improved. The same logic applies to incorporating multi-periods in the model. As the time horizon rises, the incentives to produce higher quality increase. Finally, instead of the experience-good approach, an alternative is to assume one period only and allow the foreign firm to produce mixed qualities, in which case multiple equilibria can arise and policy recommendations will become complicated.

[13] For example, Japan's food self-sufficiency rate stood at 39 percent in 2006, the lowest level in industrialized countries. Rice, eggs and a few other types of food are the only food items the country currently produces sufficiently to meet domestic demand (The Daily Yomiuri, November 4, 2008).

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