Strategic Trade Policies and Food Trade

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Makoto Tawada [1] **Madoka Okimoto** [2]

[1] Department of Economics - Aichi Gakuin University (3-1-1, Meijo, Kita-ku, Nagoya, 462-8739, JAPAN; E-mail address: mtawada2@dpc.agu.ac.jp)

[2] Graduate School of Economics - Nagoya University (Furo-cho, Chikusa-ku, Nagoya, 464-8601, JAPAN; Tel: +81-568-84-9118; E-mail address: okimoto@soec.nagoya-u.ac.jp)

ABSTRACT

Unfavorable food inflows from foreign countries are possible. Due to the increasing volume of food trade, either inspection costs are very large or the inspection quality is degraded. One solution is to charge food-trading companies for inspection costs. To this end, we create a model that delivers a game between the government of the food-importing country and foreign food firms. We then show that under a given unit inspection budget, the optimal tariff rate is the one that balances inspection costs with tariff revenue. We also show that for a greater unit inspection budget, foreign firms' mixed rate of bad food is smaller, and the tariff rate imposed on the foreign food is larger if the direct effects of a change in the unit inspection budget to the tariff overwhelm the indirect effects.

KEYWORDS: Food safety, Tariff, Inspection, Strategic trade policy

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Correspondence to:

Madoka Okimoto

1. Introduction

In the age of globalization, the transportation system has become well-developed and free trade has become widespread. The recent changes in the global society have particularly affected the food industry. Currently, people can consume all kinds of food produced over long distances with the development of preservation technology that does not damage the food's quality. We can even enjoy fresh food produced in distant foreign countries. Food trade has become quite active. There are specific characteristics of security, safety and the natural environment associated with the trade of food. In terms of safety, an exporting country's government will not care much about the health of foreign people. Alternatively, the safety standards of food may be different among the countries. Thus, unfavorable food inflows from a foreign country may occur. In contrast to other goods, with food, it is usually very difficult for consumers to distinguish between bad food and good food, which is vital given that food is directly related to the lives of human beings.

A food production firm may try to reduce production costs by mixing in low-quality materials, which may damage people's health. Consumers are usually unable to figure out in detail what materials are used for food. This incentive is likely strengthened when food is produced in a foreign country because it is difficult for the importing country government to inspect foreign firms directly and punish them for supplying bad food. In fact, examples of this problem appeared between Japan and China concerning toxic dumplings and, recently, between China and Taiwan concerning tainted cooking oil.[1] It is well known that beef, a part of which is made from cows infected with BSE, has become a diplomatic issue among many countries. We should also notice that the scientific evidence about safety in production processes may matter. For instance, chlorinated chickens, hormone beef, some chemical fertilizers and GMOs have come into question regarding health safety.

Hence, the government of the food-importing country has to inspect the imported food. With economic globalization, due to the increasing volume of food trade, either inspection costs are very large or the inspection quality is degraded. In fact, the U.S. government has experienced a rapid increase in inspection costs and is facing difficulties keeping the inspection system of imported food sound. One solution to this difficulty is to charge inspection costs to food-trading companies. The Australian government actually charges all inspection costs to food importers based on the

[1] The problem of toxic dumplings occurred between Japan and China in January, 2008. The tainted cooking oil problem occurred between China and Taiwan in September, 2014.

imported food control regulations of 1993. The Japanese government has a system to protect against inflows of bad food by imposing foreign a certificate issued by authorities designated by the government on high-risk food companies; those firms have to pay the cost of inspection to get the certificate.[2] Many trading companies complain about these policies. Thus, it is necessary to evaluate policies of this type from an economic point of view. In the present paper, we address food trade by focusing on this safety aspect and evaluate a food inspection policy where inspection costs are charged to the trading companies. It is revealed that the policy is reasonable in terms of the economic efficiency of the importing country.

Concerning trading with risk, there have been many studies on topics such as illegal migration and smuggling; however, studies on food trade regarding unhealthy food are sparse.[3] In the context of the food trade under asymmetric information, Calzolari and Immordino (2005) consider the case where food produced by an innovative technology causes health issues in the consumers of that food. They assess the political decision of whether to ban or approve food produced under such a new production technology. Cardebat and Cassagnard (2010) address the illegal production processes of foreign firms under asymmetric information, so their model resembles our case, but the purpose is quite different. In addition, their model is much more complicated because they introduce the possibility of a boycott of the illegal food and assume imperfect competition prevails in the food industry. Because of this, the properties of the equilibrium are ambiguous, and the results are heavily dependent on the simulation analysis.

To investigate the above-mentioned topic, we construct a model in which foreign firms are competing with domestic firms and reduce production costs by mixing in low-quality materials in the production process. The low-quality food may cause health issues for the consumers. Nevertheless, the lower income class of consumers may prefer the unhealthy food because of its low price. In our model, the importing government wants domestic consumers to enjoy sound food from a national welfare point of view. Thus, the importing government needs to inspect the imported food and ban bad food from being imported. Foreign firms, facing the possibility of illegal food being detected, aim to maximize their profits by mixing lower material into their products. Therefore,

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[2] See the report of Mitsubishi Research Institute (2008) for the food inspection systems of the U.S. and Australian governments. As for the Japanese food inspection system, see the Japanese Ministry of Health, Labor and Welfare Website (2014).

[3] See, for instance, Ethier (1986), Bond and Chen (1987) and Djajic (1997) for illegal migration and Bhagwati and Hansen (1973), Kemp (1976), and Martin and Panagariya (1984) for smuggling.

we consider a game between the welfare-maximizing home government and profit-maximizing foreign firms. In our setting of the game, we employ a special assumption that, under a given inspection cost, the home government will use a tariff policy to control the inflow of bad foreign food. Thus the strategic variable of the home government is a tariff rate imposed on the foreign food, while that of the foreign firms is the mixed rate of bad food. In this game, we investigate the properties of the response function of each player and the equilibrium of this game and make a comparative static analysis of the equilibrium.

The paper is organized as follows: The next section introduces the model. Section 3 is devoted to the preliminary analysis. The properties of the response function of each player and those of a full equilibrium are investigated in Section4. The last section proposes our concluding remarks.

2. Model

Consider an economy consisting of a domestic country and a foreign country. In each country, there are profit-maximizing firms in food production. Although some studies like Cardebat and Cassagnard (2010) assume the existence of oligopolistic firms, it seems to be more realistic to suppose that many small firms are engaged in food production. Hence, it is assumed that all firms are perfectly competitive in both countries. We suppose that consumers exist only in the home country. Thus, all of the food produced in the foreign country is exported to the home country and all of the food produced in the home country is domestically consumed in the home country. We call the home country country H and the foreign country country F. Moreover, we call firms in country H home firms and firms in country F foreign firms.

Country H regulates food quality by adopting a certain quality standard and applies this standard to all food consumed in the country. We assume that home firms produce food under an identical constant marginal cost c^H and supply the food satisfying the quality standard. In contrast, foreign firms produce food using a production process where they can reduce the production costs by mixing in low-quality materials. If food is produced with such low-quality materials, it will not satisfy the quality standard adopted by the home country and will cause health issues to those who consume it. We assume that both types of food look the same superficially to consumers, so consumers cannot distinguish between safe food and bad food. Consumers can, however, distinguish between foreign and domestic products based on their labels and have knowledge that some bad food is mixed in foreign food but not in the home food. Consumers are also aware of the health risks of consuming bad food.

We suppose that consumers are uniformly distributed in $[0,1]$ and each consumer will buy one unit of food at most. A consumer of type θ, where $\theta \in [0,1]$, has disutility θ for the risk of consuming bad food. Now let us define α as the probability that a consumer chooses bad food when he/she buys the foreign food. All consumers have utility U for one unit of food. Therefore, defining p^H and p^F as the prices of home food and foreign food, respectively, the consumer surplus of type θ is exhibited as $CS^H(\theta) = U - p^H$ or $CS^F(\theta) = U - (1+\theta)\alpha b - p^F$, respectively, according to the case where domestic food or foreign food is consumed. In the above formulation of $CS^F(\theta)$, b is defined as the disutility of consuming the bad food, so that αb and $\theta\alpha b$ imply the expected disutility of consuming bad food and the disutility against facing such a risk, respectively.

Each consumer will buy the food that brings forth the highest positive consumer surplus. Therefore, the condition for a consumer θ to buy home food is that $U - p^H \geq U - (1+\theta)\alpha b - p^F$, or, equivalently, $\theta \geq (p^H - p^F - \alpha b)/\alpha b$ and $U - p^H \geq 0$. Likewise, the condition for a consumer θ to buy foreign food is that $U - p^H \leq U - (1+\theta)\alpha b - p^F$, or, equivalently, $\theta \leq (p^H - p^F - \alpha b)/\alpha b$ and $U - (1+\theta)\alpha b - p^F \geq 0$, or $(U - p^F - \alpha b)/\alpha b \geq \theta$.

Now we place the following assumption.

Assumption 1 $U - p^H > 0$ and $p^H - p^F - \alpha b > 0$.

Under this assumption, consumer θ will buy domestic food if $\theta \geq (p^H - p^F - \alpha b)/\alpha b$ and buy foreign food if $\theta \leq (p^H - p^F - \alpha b)/\alpha b$. This is illustrated in Figure 1.

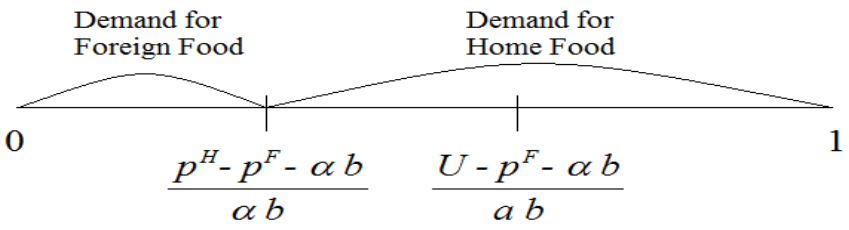

Fig. 1 Threshold and Demands for Food

We turn our attention to the production side. All home country firms produce only sound food under the common constant marginal cost, c^H, whereas any foreign country firm has an incentive to produce bad food to reduce its production costs. Let the

probability to produce bad food be β and the expected marginal cost be $c^F = c^F(\beta)$, where we assume $c^F_\beta \equiv dc^F/d\beta < 0$ and $c^F_{\beta\beta} \equiv d^2c^F/d\beta^2 > 0$.[4] The assumption that $c^F_{\beta\beta} > 0$ is necessary for the expected profit-maximizing foreign firms to determine the optimal probability to produce bad food.

We first consider the profit-maximizing behavior of a typical home firm, which is described as follows:

(H) $$\underset{x^H}{Max}\, \pi^H = p^H x^H - c^H x^H,$$

under perfect competition, where x^H is the amount of food produced by the home firm.

Next, for a typical risk-neutral foreign firm, its expected profit-maximizing behavior is expressed as follows:

(F) $$\underset{x^F,\beta}{Max}\, \pi^F = (1-\delta)\hat{p}^F x^F - c^F(\beta)x^F,$$

under perfect competition, where δ is the probability of bad food being detected when the firm produces it, $\hat{p}^F$ is the export price of the foreign food, and x^F is the amount of food produced by the foreign firm. In the above description of the profit-maximizing behavior, we suppose that the detected bad food has to be thrown away, but no fine is imposed on the detected bad food because the home government cannot punish any foreign firms.

Our final step to describe our model is to explain the home government's behavior. The aim of the home country government is to maximize the welfare of the home country when adopting policies. Here, we consider two policies. One policy is a tariff policy, and the other is an inspection policy. The home government imposes a tariff on the food imported from the foreign country. Let the tariff rate be t. The consumer price of the imported food is $\hat{p}^F + t \equiv p^F$. Concerning the inspection policy, the government uses an average cost g for the inspection of one unit of imported food. The bad food is necessarily detected if $g = \bar{g}$, but some bad food passes into the home market if $g < \bar{g}$. The government picks some samples randomly and examines them with the cost of $\bar{g}$ for one unit inspection. Suppose the government prepares the budget g for the average cost of one unit inspection. Then, the probability of detecting

[4] Each firm makes a decision on whether it produces bad food according to the probability β.

bad food from the foreign country is as follows:

$$\sigma = \frac{gX^F}{\bar{g}X^F} = \frac{g}{\bar{g}} \equiv \sigma(g),$$

where X^F is the total foreign food exported to the home country. Obviously, $\sigma'(g) = 1/\bar{g} > 0$ and $\sigma''(g) = 0$.

Denoting $T \equiv (p^H - p^F - \alpha b)/\alpha b$, we obtain the total demands of the home food and foreign food as $1-T$ and T, respectively. Therefore, the social welfare of the domestic country is represented by the following:

$$SW = \int_T^1 (U - p^H)d\theta + \int_0^T [U - (1+\theta)\alpha b - p^F]d\theta - gX^F + tT, \tag{1}$$

where the first and second terms represent consumer surpluses accrued from the consumption of the home food and foreign food, respectively, gX^F is the cost of an inspection and tT is the tariff revenue. The government tries to maximize (1) with respect to g and /or t.

3. Preliminary Analysis

Concerning the optimization problem (H), the zero-profit condition of the firm means the following:

$$p^H = c^H. \tag{2}$$

As for the foreign firms, the optimization problem (F) brings forth the following zero-profit condition:

$$(1-\delta)\hat{p}^F - c^F(\beta) = 0, \tag{3}$$

with the first order condition for optimal β:

$$-\sigma\hat{p}^F - c^F{}'(\beta) = 0, \tag{4}$$

where the second order condition, $-c^F{}''(\beta) < 0$, is satisfied by assumption.

To inspect (1) in detail, we should notice that $\delta = \beta\sigma(g)$, $\alpha = \beta(1-\sigma(g))$ and $X^F = T/(1-\beta\sigma(g))$. Moreover, $p^H = c^H$ and $p^F = \hat{p}^F + t = c^F(\beta)/(1-\beta\sigma(g)) + t$, in view of (2) and (3). Hence, we obtain the following:

$$\begin{aligned}
SW &= \int_T^1 (U - p^H)d\theta + \int_0^T [U - (1+\theta)\alpha b - p^F]d\theta - gX^F + tT \\
&= U - p^H + \int_0^T [p^H - (1+\theta)\alpha b - p^F]d\theta - gX^F + tT \\
&= U - p^H + \left[(p^H - p^F - \alpha b)\theta - \frac{1}{2}\alpha b\theta^2 \right]_0^T - gX^F + tT \\
&= U - p^H + (p^H - p^F - \alpha b)T - \frac{1}{2}\alpha bT^2 - gX^F + tT \\
&= U - p^H + \alpha bT^2 - \frac{1}{2}\alpha bT^2 - gX^F + tT \\
&= U - p^H + \frac{1}{2\alpha b}(p^H - p^F - \alpha b)^2 - gX^F + tT. \qquad (5)
\end{aligned}$$

We also obtain the following:

$$X^F = \frac{p^H - p^F - \beta(1-\sigma(g))b}{\beta(1-\sigma(g))b(1-\beta\sigma(g))} = \frac{p^H - \hat{p}^F - t - \beta(1-\sigma(g))b}{\beta(1-\sigma(g))b(1-\beta\sigma(g))}. \qquad (6)$$

4. Game

We are now in a position to explain a game between the foreign firms and the home government. To maximize the welfare of the home country, the home government can use two policies against the imported food: one is a tariff policy, and the other is an inspection policy. There are several suppositions concerning the home government's behavior:

(a) Given the budget for the inspection of bad food, the home government tries to maximize the country's welfare with the use of a tariff imposed on imported food.

(b) Given the tariff rate, the home government determines the budget scale for the inspection of the bad food to maximize the country's welfare.

(c) The home government uses both policies to maximize the home country's welfare.

In our present analysis, we address case (a) and refer to the other cases briefly in the last section. In case (a), the optimal condition for government behavior is as follows:

$$\frac{dSW}{dt} = \frac{1}{\alpha b}(p^H - p^F - \alpha b)(-1) + \frac{1}{\alpha b}(p^H - p^F - \alpha b) + t\frac{dT}{dt} - g\frac{dX^F}{dt}$$
$$= \frac{1}{\alpha b}\left(-t + \frac{g}{1-\beta\sigma(g)}\right) = 0. \qquad (7)$$

In addition, because $d^2SW/dt^2 = -1/ab < 0$, the second order condition is assured.

In what follows, we consider a non-cooperative game in which foreign firms use the value of β and the home government uses the value of t as strategic variables. In this game, the reaction function of the foreign firms is expressed by (4), and that of the home government is expressed by (7).

First, we investigate the properties of the reaction function of foreign firms. It is obvious by (4) that the optimal β for the firms has nothing to do with the level of the tariff rate t. Therefore, we can see in Figure 2 that the reaction curve of the foreign firm becomes a horizontal line, like line A.

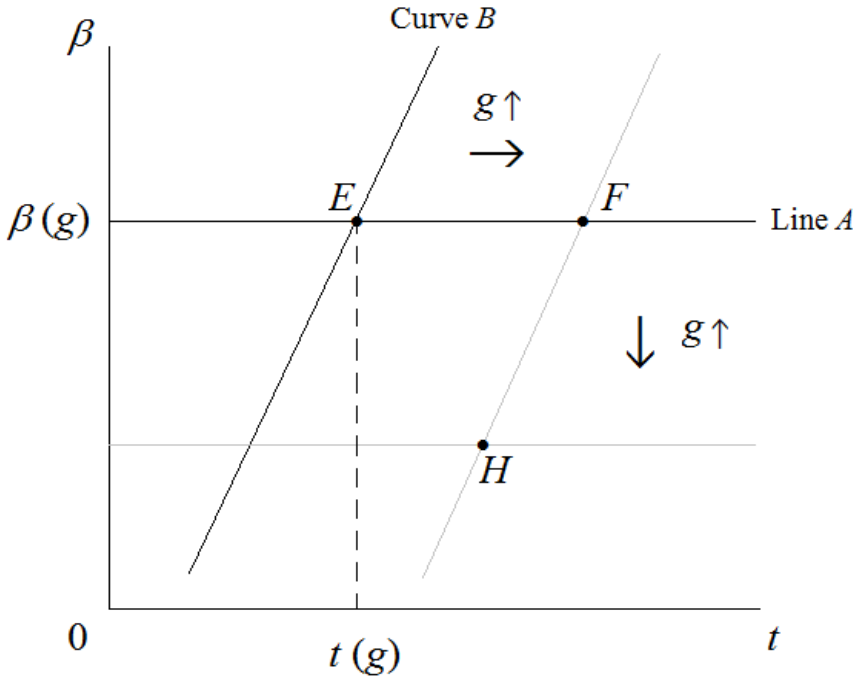

Fig. 2 Reaction Curves

Total differentiation of (4) yields the following:

$$\frac{\sigma'(g)c^F(\beta)}{1-\beta\sigma(g)}\left(1+\frac{\beta\sigma(g)}{1-\beta\sigma(g)}\right)dg+\left\{\frac{\sigma(g)[c^F{}'(\beta)(1-\beta\sigma(g))+c^F(\beta)\sigma(g)]}{(1-\beta\sigma(g))^2}+c^F{}''(\beta)\right\}d\beta=0,$$

from which we obtain

$$\frac{d\beta}{dg}=-\frac{\sigma'(g)c^F(\beta)\left(1+\dfrac{\beta\sigma(g)}{1-\beta\sigma(g)}\right)}{(1-\beta\sigma(g))c^F{}''(\beta)}<0, \tag{8}$$

because $c^F{}'(\beta)(1-\beta\sigma(g))+c^F(\beta)\sigma(g)=0$ in view of (3) and (4). This implies that a rise in g reduces to a fall in β. The reaction curve, line A, thus shifts downward with an increase in g, as in Figure 2.

Now we obtain the following:

Theorem 1

(I) Foreign firms determine their probability of producing bad food independently of the level of tariffs imposed by the home government.

(II) When the domestic government adopts more severe inspection, foreign firms reduce their probability of producing bad food.

As for (I) of Theorem 1, the tariff affects only the amount of imported food through the demand for the foreign food. However, foreign firms produce food under perfect competition so they do not care about the output level under constant returns to scale technology. Thus, the probability β optimal to the firms has nothing to do with the level of tariffs. (II) of Theorem 1 simple means that foreign firms decrease the probability β to control an increase in risk because the reinforcement of inspections increases the risk of bad food being detected.

Next, we will investigate the reaction function of the home government expressed by (7). Under the assumption that $\beta>0$ and $g>0$, the tariff t satisfying (7) is positive because

$$t=\frac{g}{1-\beta\sigma(g)}>0.$$

With the above equation, we also obtain the following:

$$\frac{\partial t}{\partial \beta} = \frac{g\sigma(g)}{(1-\beta\sigma(g))^2} > 0 \quad \text{and}$$

$$\frac{\partial t}{\partial g} = \frac{1-\beta\sigma(g)+\beta\sigma'(g)}{(1-\beta\sigma(g))^2} > 0.$$

Finally (7) yields

$$tT - gX^F = \left[t - \frac{g}{1-\beta\sigma(g)} \right] T = 0, \tag{9}$$

implying that the optimal reaction for the home government is to balance the tariff revenue and the total cost of inspection.

Now, we can summarize the properties of the optimal reaction of the home government as follows:

Theorem 2

Concerning the tariff reaction of the home government,

(I) For any given $\beta > 0$ and $g > 0$*, the tariff rate is positive.*

(II) The tariff reaction against β *is such that the tariff revenue is balanced with inspection costs; thus, the tariff rate is zero if there is no inspection.*

(III) A rise in the probability for the foreign firms to produce bad food raises the tariff rate.

(IV) An increase in the budget for inspection raises the tariff rate.

Among the results in Theorem 2, the most interesting and important is (II), which can be interpreted as follows: If the tariff revenue is more than the total inspection costs, the economy becomes inefficient due to the trade barrier of too heavy tariffs. Conversely, if the tariff revenue is less than the total inspection cost, the implementation of market failure becomes costly. Under the given inspection cost, therefore, the government's best tariff strategy is to cover the inspection costs with the tariff revenue. The tariff policy is equivalent to a certification policy where the government inspection cost is charged to the exporting firms. Hence, some governments, such as the Australian and Japanese governments, for example, adopt a certification policy because the direct application of a

tariff policy becomes difficult under the global movement of free trade.

(I) is a natural conclusion from (II). The reason for (III) is that a rise in the probability β by the foreign firms enlarges risk to the home consumers to consume bad food; hence, the home government tries to reduce this risk with a rise in tariffs to discourage foreign firms from exporting such food. (IV) simply means that an increase in the expenditures for inspection should be covered by the tariff revenue by (II).The level of the tariff rate thus increases. Because of (III) and (IV), the reaction curve of the home government slopes negatively, which is illustrated as curve B in Figure 2, and shifts to the right with an increase in g.

We can now see an equilibrium of the game between foreign firms and the home government. The equilibrium of the game is characterized by two equations, (4) and (7), which determine β and t under $g \geq 0$. Therefore, we express these equilibrium β and t by $\beta(g)$ and $t(g)$, respectively. In Figure 2, the equilibrium pair of $\beta(g)$ and $t(g)$ is displayed by point E. Once g becomes larger, the reaction curves A and B move downward and to the right, respectively. Hence, clearly, equilibrium point E moves to point H, where the new reaction curves are intersecting. It is easy to see from this illustration that an increase in g decreases $\beta(g)$, but whether $t(g)$ rises or falls is ambiguous.

To investigate the movement of $t(g)$ in greater detail, we calculate dt/dg. We obtain the following

$$dt = \left.\frac{\partial t}{\partial g}\right|_{(7)} dg + \left.\frac{\partial t}{\partial \beta}\right|_{(7)} \left.\frac{d\beta}{dg}\right|_{(4)} dg$$

$$= -\frac{g\sigma(g)}{(1-\beta\sigma(g))^2} \frac{c^F(\beta)\sigma'(g)\left(1+\dfrac{\beta\sigma(g)}{1-\beta\sigma(g)}\right)}{(1-\beta\sigma(g))c^F{}''(\beta)} + \frac{1-\beta\sigma(g)+\beta\sigma'(g)}{(1-\beta\sigma(g))^2}, \quad (10)$$

where $[\partial t/\partial g]_{(7)}$ is the partial derivative of (7), for example. The first and second terms of RHS of (10) show the indirect and direct effects, respectively. In Figure 2, the direct effect is expressed by a shift in t from E to F, whereas the indirect effect is a shift in t from F to H. The direct effect implies that, for an increase in g, the home government raises t to cover an increase in the inspection costs. In contrast, the indirect effect means that, with an increase in g, foreign firms lower β, and the home government reacts to this lowering of β with the reduction of t. The direct effect is positive, whereas the indirect effect is negative. Hence, $dt/dg > (<)0$, if and only if the direct effect is greater (less) than the indirect effect.

We also see that the degree of consumer disutility caused by consuming bad food has nothing to do with the full equilibrium. This is because neither equation (4) nor equation (7) contains b. The reason for this result is that b can affect only the food supply of foreign firms through the demand for the foreign food, but β is determined independently of the foreign production level. Moreover, b can affect the tariff revenue of the home government through the demand for foreign food but it cannot be influential to t because of the optimal condition that the tariff revenue has to be balanced with the total inspection cost, that is, $tT - gX^F = [t - g/(1-\beta\sigma(g))]T = 0$.

The following theorem is a summary of the above results on the full equilibrium.

Theorem 3

Under a given nonnegative g, there is a unique nonnegative equilibrium pair of β and t. $t = 0$ and $\beta > 0$, if and only if $g = 0$. For a greater g, the equilibrium value of β is smaller and that of t is larger (smaller) if the direct(indirect) effect of g to t overwhelms that of the indirect (direct) effect. Finally, the equilibrium values of β and t are never affected by the degree of consumer disutility caused by consuming bad food.

5. Concluding Remarks

In this paper, we investigated an optimal tariff on foreign food, which is possibly harmful to consumers' health. The framework we employed is a game between the importing country's government and the exporting countries' firms. The strategic variables of the government and the firms are an import tariff to control the import amount and a mixed rate of bad food to reduce production costs, respectively.

We showed that, under a given unit inspection budget, the optimal tariff rate is the one that balances all inspection costs with the tariff revenue. Thus, no tariff is the optimal strategy for the importing government if there is no inspection on the imported food. We also showed that, for a greater unit inspection budget, foreign firms' mixed rate of bad food was smaller, and the tariff rate imposed on the foreign food by the government was larger (smaller) if the direct (indirect) effect of a change in the unit inspection budget to the tariff on foreign food overwhelmed the indirect (direct) effect. Finally, we revealed that the equilibrium values of the mixed rate of bad food and the tariff rate on foreign food were never affected by the degree of consumer disutility caused by receiving bad food.

Although our attention has been centered on the tariff policy of a food-importing country, the analysis of a strategic inspection policy is another interesting and

important topic. In fact, we examined this topic in the present framework, but the optimal condition to obtain the government reaction function of g to β was so complicated that the properties of the full equilibrium were blurred. Thus, we do not extend our analysis to this case. To tackle this case, we need a simplification of the model. Even in this case, however, our result that the inspection costs must be equal to the tariff revenue carries over.

Finally, if we consider the case that the importing country fines foreign firms exporting bad food, we might infer from our analysis that the optimal fine is such that the total revenue from the fine is balanced with total inspection costs. A detailed analysis of this case is explored by Tawada and Okimoto (2014).

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