How to Supply Safer Food: A Strategic Trade Policy Point of View *

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Abstract

This paper examines how a tariff affects firms' efforts to produce safer foods that are supplied to consumers whose preference for safety of foods are different. I analyze the optimal trade policy for importing country that can impose a tariff or a subsidy on the foods. I show that the raise in tariff rate makes importing country's firm chooses less effort to produce safer foods but foreign firm works harder to enhance product safety if importing contry's government levies a tariff on imports, and vice versa. I find a small tariff improves domestic welfare. It increases domestic firm's profit, consumer surplus who buy goods from domestic firm and tariff revenue.

JEL Classification: F12; F13; L13
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1 Introduction

In recent years, many food safety-related incidents have been occurred in Japan both domestically and internationally. Insecticide-tainted dumplings from China, for example, caused food-poisoning in Japan during 2007-2008.

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At least 175 Japanese people reportedly got food poisoniong [1]. In addition, Chinese dairy producers had added melamine to milk to supplement protein levels in milk and it became obvious in 2008. Several babies died and tens of thousands of children sickened after consuming powdered tainted-milk in China. In Japan, although barely any milk or other dairy products are imported from China, a substantial volume of processed foods were made using Chinese milk. These incidents have increased public awareness of food safety problems in Japan.

The uncertainty about product safety arises as a result of practical matters such as a producer's inability to strictly control all of the inputs or processes that determine the safety of a manufactured product. Consequently, government intervention on firms' decision about effort to enhance safety is required to ensure safety of goods. It is desirable for importing country that its government dictates safety level of all goods which are distributed nationally including imported goods when goods are internationally traded. But it may be difficult in practice because government has incomplete information about goods (for example, raw materials, production process and so on). As regards firms located in foreign, in particular, importing country's government is hard to obtain information about their goods. Then government will try to control the effort levels through trade policy. In this paper, I assume she imposes a tariff on imports and try to affect firms' effort decision about product safety.

I allow the case that all foods are not necessarily safe. The degree of the safety of foods depends on firm's efforts and, I suppose for simplicity, it equals to the probability of safe foods that each firm produces. It is generally recognized that it is rarely possible or economically feasible to achieve zero risk with respect to safety, even if such a conclusion is not always socially accepted (Marette (2007)).

This paper considers the case that goods are differentiated by their safeness and it depends on firms' efforts to supply safety products. I show that domestic firm niglects to make effort to improve safety of foods but foreing firm makes more effort to produce safer foods if domestic government raises tariff rate. Because the raise in tariff rate increases price of foreign firm's foods even though their safetness does not change, demand for them decreases. So foreign firm enhances safety to try to prevent reduction in demand. Foods' price of domestic firm also increases if domestic government raises tariff rate. But in fact ralative price of them decreases. It boosts demand for domestic firm's foods and she can neglect to make costly effort.

[1]See The New York Times published in February 2, 2008. http://www.nytimes.com/2008/02/02/world/asia/02japan.html.

And I show that a small tariff improves importing country's welfare. It increases domestic firm's profit, consumer surplus of her goods and tariff revenue. Then it improves domestic welfare , although consumer surplus of foreign firm's foods is decreased by it.

There is a considerable literature on regulation of food safety or product safety. Among others Zhou et al. (2002), Das and Donnenfeld (1989) and Marette (2007) are very important preceding studies in view of my analysis made in this paper. Zhou et al. (2002) analyze the effects of subsidy or tax on improvement in quality from the exporting countries' view point. They construct the third market model and show that optimal policies of exporting countries depend on the form of competition in the third country market.

Das and Donnenfeld (1989) construct two-country model to take into account international trade and examine optimal trade policy from the point of view of importing country. They compare Minimum Quality Standard with quota and conclude that quota is superior policy from the point of view of domestic welfare.

Marette (2007) explores the effects of minimum safety standard which determinate a minimum level of care influencing the safety probability with which all sellers should comply in offering their products) with uncertainty about product safety under perfect and imperfect contexts of information. He assumes that consumers purchase only the products which are safe with probability 1 under perfect information.

In this paper, I consider the context where consumers may buy products which are safe with probability less than 1. In reality, perfect safety is hard to achieve and consumers are exposed to risk. For example, Snow Brand's low-fat milk caused the outbreak of food poisoning in 2000, and the the number of food poisoning cases exceeded 10,000 (Ota and Kikuchi).

This paper is organized as follows. Section 2 presents the basic model with two countries and two firms. Section 3 derives market equilibrium and importing country's choice are successively detailed. Finally, in section 4 some concluding remarks are presented.

2 The model

Suppose there are two countries, home and foreign, and each country has one firm that produces food product. I call the firm in home country firm 1 and the firm in foreign country firm 2. Both firms supply to the domestic market with either safe food or poisonous food that they produce. And they compete with each other *a la* Bertrand in the domestic food market. As usual in an international trade model, I assume transport cost of the

product is zero. Meanwhile, I assume each firm i's ability to reduce risk to produce poisonous or less safe food is $F(\lambda_i)$ where λ_i is firm's effort which is equivalent to probability of a safe food emerging. And I assume that $F'(\lambda_i) > 0,\ F''(\lambda_i) > 0$. For simplicity, I let the firm's effort be equivalent to the probability of emerging safe product. With probability $\lambda_i\ \ (\lambda_i \in (0, 1])$, firm i supplies safe food and with probability $1-\lambda_i$, firm i supplies poisonous food to the domestic market. In order to simplify the analysis I also assume that firm 1 always makes more efforts than firm 2, so $\lambda_1 > \lambda_2$ holds through out the paper.

Suppose consumers are risk neutral and to purchase only one unit of food product. And they can observe the value of λ_i. Their marginal willingness to pay for safety, α, is uniformly distributed over a unit interval, $[\alpha_l, \alpha_h] \equiv [\alpha_l, \alpha_l+1]$ where α_l (α_h) represents the lowest (highest) level of α and $\alpha_l \geq 0$. I assume a consumer's utility level becomes $\alpha s + Y$ if he consumes safe food and $\alpha d + Y$ if he consumes poisonous food. Therefore, his net expected utility level or consumer's surplus of consuming food i is equal to $U(\alpha, \lambda_i) = \alpha\{\lambda_i s - (1-\lambda_i)d\} + Y - p_i$, where p_i represents the price of food i. In order to assure every consumer purchase one unit of food product the income level satisfies following inequality:

$$\alpha_l d + p_2 > Y \geq -\alpha_l\{\lambda_2 s - (1-\lambda_2)d\} + p_2. \tag{1}$$

Domestic government intervenes into food market with imposing an import tariff. She seta a tariff rate t by taking into account each firm's decisions.

The timing of this game is divided into three stages. In the first stage, domestic government chooses a tariff rate that maximizes domestic welfare. She influences each firm's effort to produce safe food. In the second stage, each firm chooses own effort level that is equal to the probability of producing safe food. And in the third state, firms compete in the food market by choosing price level.

3 Analysis

Along the spectrum of marginal willingness to pay, there exist a marginal consumer, $\bar{\alpha}$, who is indifferent between consuming safer food (i.e. food from firm 1) and less safe food (i.e. food from firm 2) [2] . Thus $\bar{\alpha}$ is defined as

[2]Notice that in this paper each consumer cannot recognize whether the particular food he purchase is safe or poisonous. However, he knows the probability distribution of food safety of each firm's food product: he knows firm i's probability is λı and if he consume firm i's food he will get net utility $\alpha\lambda_i s - p_i + Y$ with probability λ_i, and $-\alpha(1-\lambda_i) - p_i + Y$ with probability $(1-\lambda$ı$)$. Under the circumstance of $\lambda_1 > \lambda_2$, they regard firm 1 supplies safer food and firm 2 supplies less safe food to the market.

$\bar{\alpha} = (p_1 - p_2)/\{A(\lambda_1 - \lambda_2)\}$ where $A \equiv s + d$. Assuming that the firms have perfect information about distribution of α, the demands facing each firm are $x_1 = \alpha_l + 1 - \bar{\alpha},\ x_2 = \bar{\alpha} - \alpha_l$, respectively.

Now I solve the game using backward induction. First I solve the third stage. In period 3, the firms compete against each other *a la* Bertrand. Thus period 3, firms chooses their prices to maximize their profit:

$$\pi_1(p_1, p_2, \lambda_1, \lambda_2, t) = p_1 x_1 - F(\lambda_1), \quad \pi_2(p_1, p_2, \lambda_1, \lambda_2, t) = p_2 x_2 - F(\lambda_2) - t x_2$$

respectively. The equilibrium price, quantities and the profits become:

$$\begin{aligned} \tilde{p}_1(\lambda_1, \lambda_2, t) &= \frac{(\alpha_l + 2)A(\lambda_1 - \lambda_2) + t}{3}, \\ \tilde{p}_2(\lambda_1, \lambda_2, t) &= \frac{(1 - \alpha_l)A(\lambda_1 - \lambda_2) + 2t}{3}, \end{aligned} \tag{2}$$

$$\begin{aligned} \tilde{\pi}_1(\lambda_1, \lambda_2, t) &= \frac{\{(\alpha_l + 2)A(\lambda_1 - \lambda_2) + t\}^2}{9A(\lambda_1 - \lambda_2)} - F(\lambda_1), \\ \tilde{\pi}_2(\lambda_1, \lambda_2, t) &= \frac{\{(1 - \alpha_l)A(\lambda_1 - \lambda_2) - t\}^2}{9A(\lambda_1 - \lambda_2)} - F(\lambda_2). \end{aligned} \tag{3}$$

In the second stage, or period 2, the efforts (equal to the probability of getting safe products) are determined by taking into account the decisions in period 3. Firms choose effort levels λ_i which maximize (3). The first-order conditions for profit-maxmizing are following [3] :

$$\begin{aligned} \frac{\partial \pi_1}{\partial \lambda_1} &= \frac{(2\alpha_h - \alpha_l)^2 A^2 (\lambda_1 - \lambda_2)^2 - t^2}{9A(\lambda_1 - \lambda_2)^2} - F'(\lambda_1) = 0, \\ \frac{\partial \pi_2}{\partial \lambda_2} &= \frac{(\alpha_h - 2\alpha_l)^2 A^2 (\lambda_1 - \lambda_2)^2 - t^2}{9A(\lambda_1 - \lambda_2)^2} - F'(\lambda_2) = 0. \end{aligned} \tag{4}$$

To determine the effects of a tariff lavied by domestic government, I totally differentiate equation (4) to obtain

$$\begin{pmatrix} A & -2t^2 \\ 2t^2 & B \end{pmatrix} \begin{pmatrix} \mathrm{d}\lambda_1/\mathrm{d}t \\ \mathrm{d}\lambda_2/\mathrm{d}t \end{pmatrix} = \begin{pmatrix} 2t(\lambda_1 - \lambda_2) \\ 2t(\lambda_1 - \lambda_2) \end{pmatrix} \tag{5}$$

where $A \equiv 2t^2 - 9A(\lambda_1 - \lambda_2)^3 F''(\lambda_1) < 0,\ B \equiv -\{2t^2 - 9A(\lambda_1 - \lambda_2)^3 F''(\lambda_2)\} < 0$ [4] . Thus, the effects of a change in t on effort levels are given by

$$\begin{aligned} \frac{\mathrm{d}\lambda_1}{\mathrm{d}t} &= \frac{18A(\lambda_1 - \lambda_2)^4 F''(\lambda_2) t}{\Omega}, \\ \frac{\mathrm{d}\lambda_2}{\mathrm{d}t} &= \frac{-18A(\lambda_1 - \lambda_2)^4 F''(\lambda_1) t}{\Omega}, \end{aligned} \tag{6}$$

[3] I assume the socond-order conditions for profit-maxmizing are satisfied, i.e., $\partial^2 \pi_i / \partial \lambda_i^2 < 0$.

[4] From the second-order conditions for profit-maximizing, $A < 0$ and $B < 0$.

where $\Omega \equiv -\{2t^2 - 9A(\lambda_1 - \lambda_2)^3 F''(\lambda_1)\}\{2t^2 - 9A(\lambda_1 - \lambda_2)^3 F''(\lambda_2)\} + 4t^2$. I assume $\partial^2\pi_i/\partial\lambda_i^2 < \partial^2\pi_i/\partial\lambda_j\partial\lambda_i$ $(i, j = 1, 2,\ i \neq j)$, then $\Omega < 0$.

Proposition 1

If domestic government imposes tariff on imports from foreign country, The higher the tariff rate is, the less effort firm 1 makes but the more effort firm 2 exerts to improve safety, and vice versa. Similarly, the raise in subsidy rate decreases effert by firm 1 but increases one by firm 2, if importing country's government subsidizes imports.

Intuitively, both goods' prices raise if domestic government raises tariff rate on imports. If good 2's price increases without improving product safety, then firm 2 loses market share and profit. She makes more effort to prevent consumers from defecting. On the other hand, relative price for good 1 lowers even though p_1 is raised by a tariff. So demand for good 1 increases and firm 1 can lower costly effort level as to increase in t.

In period 1, domestic government sets a tariff by taking into account the effort levels in period 2 and the prices decisions in period 3. She maximizes domestic welfare which consists of consumer surplus, firm 1's profit and tariff revenue. The expected welfare is

$$W_1 = CS + \pi_1 + tx_2.$$

The first order condition for this optimization problem which is evaluated at $t = 0$ is following:

$$\left.\frac{\mathrm{d}W^1}{\mathrm{d}t}\right|_{t=0} = \frac{1}{3} > 0. \tag{7}$$

Following proposition is apparent from (7).

Proposition 2

A small tariff improves welfare of importing country.

Domestic government imposes small tax on imports to increase consumer surplus of good 1, firm 1's profit and tax revenue. Consumer surplus of good 2 decrease in accordance with t because small tariff raise p_2 and less consumer buy good 2. But the effect of a small tariff enhances domestic welfare as a whole.

4 Concluding and Remarks

I have examined the effects of a tariff levied by importing country on firms' attention to safety of goods in international oligopoly, introducing uncer-

tainty about product safety. The analysis above has shown that the raise in tariff rate makes foreing firm exerts more effort to enhance product safety but domestic firm pays less attention if importing country's government charges tariff on imports. Likewise, the higher subsidy rate is, the more effort foreing firm makes but the less domestic firm pays attention to safety if she subsidizes foreign firm.

And I find that a small tariff increases consumer surplus of domestic goods, domestic firm's profit and tariff revenue. It improves overall welfare of importing country even though it decreases consumer surplus of import goods.

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