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by

OKIMOTO Madoka

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OKIMOTO Madoka*

In the era of increasing world population and food crisis, when choosing safe domestic foods or low-priced imported foods which may cause health damages, the bias against health risk based on consumers' personal income level can play a significant role. In this study, focusing on such biases, we analyze the determination of food price and biased demands for unsafe foods, which are affected by fluctuation of income distribution and population growth.

The results are as follows. First, when a population growth does not fluctuate the income distribution and income level, this population growth never cause price hikes. However, a population growth that expands the income difference and increases low-income bracket raises even the price of low-priced problematic foods, while the economic growth with no population growth decreases the price of problematic foods. Second, the large income difference should be reformed since the large bias makes the worsening of quality control connected with price hike. Moreover,

* 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

the improvement of food quality mitigates the problem that low-income consumers tend to suffer the health damages.

Ⅰ. Introduction

After 2006, the international prices of grain are clearly trending higher compared to the period between 1970 and 2006. Now in March 2014, they have preserved 1.3~2.6 times compared with autumn of 2006.[1)] Even if the prices of foods keep soaring in the future, however, people who belong to high income bracket can continue to buy safe and high-quality foods as they would do, while people who belong to low income bracket and have high Engel's coefficient may indeed switch the foods to low-priced one. Such a phenomenon can occur more remarkably in the developing countries where the countrywide income level is low. The problem is that those low-priced foods may involve faults with respect to their safety or quality.

On the one hand, the issue concerning nutrition and hygiene can occur being connected with the problem of food safety in the poorest counties rather than the developed countries of which the rate of food self-support is low. On the other hand, a rise in population can aggravate such problems in the long term. In 2011, United Nations Population

Fund(UNFTA) declared their forecast that world population exceeded 70 billion by the end of October 2011 and it would be over 100 billion by the end of this century in "The State of World Population 2011". The report also forecasted that African population would increase threefold to be about 36 billion by the end of the century.[2)] Then a rise in population in the region of low income can aggravate problems concerning food safety in the future. In turn even if national income level is enough high, the safety of food is problem likewise, especially in the country which possesses wide income gap. That is because wide income gap can polarize consumers into high income bracket who sticks to food safety and low income bracket who tends to be unconcerned about risk and may suffer health damages.

Our problem consciousness is therefore to analyze how fluctuations in the income distribution and the population of the economy affect prices and consumers' choices of foods, under the biased consumers' behaviors. We also argue how we can mitigate the problem that low-income consumers choose foods that may be unsafe and suffer the health damages.

In our theoretical analysis, we consider the market in one country in which domestic foods and imported foods are provided. But we suppose that health damage occurs at some rate when a consumer eats low-priced imported food. Consumers are distributed over their income, preferences towards food safety of those consumers are however biased against the publicly announced contamination rate and the bias varies depending on his or her income level. Specifically high-income consumers overestimate the contamination rate and low-income consumers underestimate the rate. Finally in order to analyze fluctuations in food price and decision-making of consumers, we consider the Bertrand competition between a domestic food firm and a foreign food firm.

Assuming that there existed asymmetric information about the production process of imported goods, Cardebat and Cassagnard (2010) analyzed exclusion of problematic imported goods by an importing government in the Bertrand competition between the north firm and the south firm. So the social problem that the paper discussed is similar to ours but this was not organized to explain bounded rationality of consumers, income fluctuations and population growth. In the context of food trade under asymmetric information, Calzolari and Immordino (2005) investigated international trade in innovative goods subject to uncertain health effects, while each firm privately observed an independent random variable as to the safety of foods and the solution concept was Perfect Bayesian Equilibrium. That means they dealt with different formulation of asymmetric information compared with ours which introduces more simple expected values and Nash Equilibrium, however the reason why they chose such a way is to study lobbying and decision of governments about the food safety through learning process. Of course, PBE is one of beautiful concept to explain the trade of risky foods and learning process, nevertheless we owe this simple explanation of food price hikes under some risks to Nash Equilibrium.

The issue concerning the bounded rationality is dealt with and analyzed in Kahneman and Tversky (1979), Herbert (1984) and various contexts. McDermott et al. (2008) suggested that people can be harmed by their inherent preference toward foods. Cawley and Ruhm (2011) overviewed the theoretical framework for and the empirical evidence on risky health behavior as smoking and drinking alcohol and so on, discussing bounded rationality and summarizing that income could either increase or decrease unhealthy behaviors.[3)] Chan and Gruber (2010) also empirically insisted that the higher income individuals were not more price sensitive and those who had chosen the lowest cost plan were more price sensitive, in the context of the choice of health plan prices by low income families. In that respect, it is our originality that we modeled not only consumers' choices based on bounded rationality affected by their incomes but also introduced the concept of income distribution and fluctuation, and economic growth and analyzed food price and safety in the economy of a population explosion by the simple model everybody can easily understand.

We organize our model in chapter 2 and in the subsequent chapters we analyze it and derive some theorems.

Ⅱ. The Model

We consider the economy composed of two countries, domestic and foreign country, and consumers are located only in the domestic country. Subsequently, we focus on the situation that foods made in the domestic country and imported foods made in the foreign country, are both provided for the market in the domestic country. The problem we set is that although the qualities of both foods are homogeneous, demanding imported food may cause health damages but there are demands for them as they enable low price. Accordingly we discuss the determination of food price and consumer behavior concerned with the health damage suffered by the consumption of imported food. For this purpose, we take account of fluctuations of population and income distribution in the domestic country, and show the relationship between food safety and income distribution and population growth.

We first suppose that consumers are in the domestic country distributed continuously and uniformly, according to their income I_i over the interval, $[\underline{I},\ 1+\alpha]$, and there are θ people on each point over that interval. Next we define $\underline{I}$ as the bottom income and $1+\alpha$

as the highest income, and then suppose $\underline{I} \geq 0$ and $\alpha > 0$ holds shown as in Figure 1.

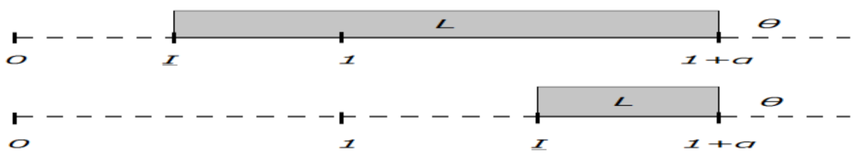

FIGURE 1 Population Distributions of Developing and Developed Economy

According to these definitions, in this model, on the one hand the higher α becomes, the wealthier the economy becomes, on the other hand the lower $\underline{I}$ becomes, the poorer the economy becomes. Although α and $\underline{I}$ can fluctuate, we suppose that the economy has the given population; given θ and making l denote the extent of income difference, we define the population as $\theta l = L$ and make α and $\underline{I}$ fluctuate to satisfy Eq.(1).

$$\theta\left(1 + \alpha - \underline{I}\right) = \theta l = L. \tag{1}$$

In other words, we express $\underline{I}$ as $\underline{I} = 1 + \alpha - l$: the level of the lowest income is determined by the level of the highest income $1 + \alpha$ and the extent of income difference l.

Such a formulation also enables α to express the income level of this economy.

Subsequently, we discuss the relationship between publicly declared contamination rate and the bias that consumers are possessed with. First we define the public contamination rate, the public ratio of all the imported foods provided to imported foods that cause the health damages, as τ and suppose that $0 \leq \tau < 1$. Accordingly, we assume $q(I_i) \equiv \tau I_i$ represent the biased contamination rate of consumer i, namely we define the contamination rate that the consumer subjectively recognizes as the function of his/her income, and assume that $0 \leq q(I_i) \leq 1$. Because of income distribution, $I_i \in [\underline{I},\ 1+\alpha]$, thereupon overestimations or underestimations of the public contamination rate originate in proportion to their incomes. In short, biases against the contamination rate arise.

Specifically, the recognition of a consumer having no income is $q(0) = \tau \cdot 0 = 0$ and the consumer can eat anything, the recognitions of consumers having low income, $I_i\colon 0 < I_i < 1$, are $q(I_i) < \tau$ and the biases encourage such consumers to underestimate the contamination rate, but the recognition of one having the income that can be yardstick, $I_i = 1$, is $q(I_i) = \tau \cdot 1 = \tau$, and he or she neither underestimates nor overestimates the rate but assesses it correctly. In the meantime, as the recognitions of consumers possessing high income, $I_i\colon 1 < I_i < 1+\alpha$, are $q(I_i) > \tau$, the biases drive those consumers to overestimate the rate and as those of consumers possessing the highest income, $I_i = 1 + \alpha$ is $q(1+\alpha) = \tau \cdot (1+\alpha)$, their biases also drive them to overestimate it.[4)]

Now, as $1 + \alpha$ or $\underline{I}$ is apart from 1, the biases grow larger. As Figure 1 suggested, in turn, we can take account of the economy that $\underline{I}$ is greater than 1. Such an economy can be regarded as a developed country, where consumers possess enough high incomes and all of consumers overestimate the contamination rate. Finally, we consider that any country should have wealthy people and suppose the highest income $1 + \alpha$ is greater than 1.

We suppose that consumer i chooses domestic foods or imported foods depending on not only prices of foods, utility gained to eat them and the cost of health damage, but also the biased subjective contamination rate, and the consumer demands at most one domestic or imported food. Define the price of domestic foods and that of imported foods as p^D and p^F. Likewise, define the utility gained to demand a food and the cost of health damage as u and D, which are to be given and constant. Subsequently, the following equation expresses the surplus for consumer, which is obtained by demanding one domestic food.

$$CS_i^D = u - p^D. \tag{2}$$

In the same way, due to $q(I_i) \equiv \tau I_i$, Eq. (3) expresses the surplus for consumer i obtained by consuming one imported food.

$$CS_i^F = (1 - \tau I_i)u - \tau I_i D - p^F. \tag{3}$$

Here we suppose that individual rationality is satisfied and subsequently a consumer purchases a food, when the consumer surplus obtained by that food is beyond 0 for him/her. Therefore, individual rationality condition(IR) are respectively represented as follows.

$$CS_i^D \geq 0 \Leftrightarrow u \geq p^D, \tag{4}$$

$$CS_i^F \geq 0 \Leftrightarrow I_i \leq \frac{u - p^F}{\tau(u + D)}. \tag{5}$$

Needless to say, $u \geq p^D$ and $u \geq p^F$ should hold for the food firms to sell consumers products. Thus we suppose $u \geq p^D$ and $u \geq p^F$, and since $u \geq p^D$ holds for any consumer, all the consumers can gain consumer surplus by demanding domestic foods, while only consumers who have low incomes and estimate the contamination rate enough low can gain surpluses by demanding imported foods, as the bias against the public contamination rate exists.

Next, we also suppose that all the consumers prefer and choose the type of food which gives the consumer higher consumer surplus, namely we suppose that the incentive compatibility condition is, for all the consumers, satisfied. The switching point indicated by incentive compatibility condition(IC) is expressed as

$$CS_i^D \gtreqless CS_i^F \Leftrightarrow I_i \gtreqless \frac{p^D - p^F}{\tau(u+D)} > 0. \tag{6}$$

If $p^D \leq p^F$ held, the switching point, $\frac{p^D-p^F}{\tau(u+D)}$ would be negative and no one would demand imported foods in this economy. This fact suggests that $p^D > p^F$ must hold in the economy where both foods are provided. As to the switching point indicated by (IC), we can consider two kinds of economy. One is the economy where $\frac{p^D-p^F}{\tau(u+D)} > \underline{I}$ holds and another is the economy where $\frac{p^D-p^F}{\tau(u+D)} < \underline{I}$ holds. In the case of $\frac{p^D-p^F}{\tau(u+D)} > \underline{I}$,[5)]

$$\frac{u-p^F}{\tau(u+D)} - \frac{p^D-p^F}{\tau(u+D)} = \frac{u-p^D}{\tau(u+D)} \geq 0,$$

holds and it suggests that the point where (IR) of imported foods vanishes is above the switching point indicated by (IC) as in Figure 2.

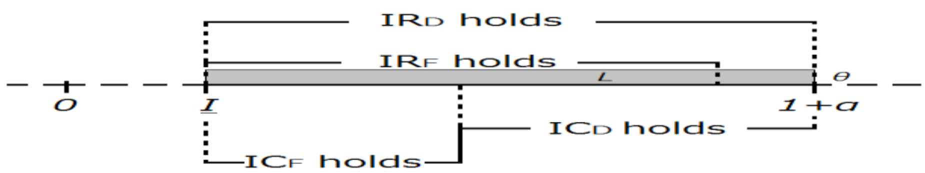

FIGURE 2 Threshold : Demands for Domestic and Imported Foods

ANNOTATION: In FIGURE 2, in the interval in which “IR_D (IR_F) holds”, Individual Rationality Condition is satisfied for consumers when they demand domestic (imported) food. Likewise, in the interval in which “IC_D (IC_F) holds”, consumers, according to Incentive Compatibility Condition, prefer domestic (imported) food to imported (domestic) food and choose domestic (imported) food.

Consequently, we define the threshold of the demands as $I^* \equiv \frac{p^D - p^F}{\tau(u+D)}$. We also denote the demand for domestic foods and that for imported foods as X^D and X^F, representing demand functions as follows:

$$X^D = \theta(1 + \alpha - I^*) = \theta\left[(1 + \alpha) - \frac{p^D - p^F}{\tau(u + D)}\right], \tag{7}$$

$$X^F = \theta\left(I^* - \underline{I}\right) = \theta\left[\frac{p^D - p^F}{\tau(u+D)} - (1 + \alpha - l)\right]. \tag{8}$$

Next, we argue the behavior of firms. Due to the risk of health damage, income difference and personal preference towards food safety, there exist market powers. Therefore, to concisely analyze price settings we define a representative domestic firm as firm D and a representative foreign firm as firm F and consider the Bertrand competition between firm D and firm F that occurs in domestic food market.

First, the decision-making of firm D is displayed as follows.

$$max_{p^D}\pi^D = (p^D - c^D)X^D = (p^D - c^D)\theta\left[(1+\alpha) - \frac{p^D - p^F}{\tau(u+D)}\right].$$

The character c^D expresses the unit cost for production of firm D. Subsequently we gain first and second order conditions, which are satisfied.

$$(f.o.c) \quad (1+\alpha) - \frac{p^D - p^F}{\tau(u+D)} + (p^D - c^D)\left[\frac{-1}{\tau(u+D)}\right] = 0, \tag{9}$$

$$(s.o.c) \quad \frac{-2\theta}{\tau(u+D)} < 0.$$

Likewise, the decision-making of firm F is exhibited as follows.

$$max_{p^F}\pi^F = (p^F - c^F)X^F = (p^F - c^F)\theta\left[\frac{p^D - p^F}{\tau(u+D)} - (1+\alpha-l)\right].$$

The character c^F expresses the unit cost to produce foods of firm F. As for this maximization problem, in the same way we obtain first and second order conditions, which are also satisfied.

$$(f.o.c) \quad \frac{p^D - p^F}{\tau(u+D)} - (1+\alpha-l) + (p^F - c^F)\left[\frac{-1}{\tau(u+D)}\right] = 0, \tag{10}$$

$$(s.o.c) \quad \frac{-2\theta}{\tau(u+D)} < 0.$$

Arranging Eq.s (9)-(10), reaction functions of each firm are derived as Eq.s(9)′-(10)′, which characterize the Bertrand equilibrium as in Figure 3.

$$p^F = -(1+\alpha)\tau(u+D) + 2p^D - c^D, \tag{9$'$}$$

$$p^F = \frac{p^D + c^F - (1+\alpha-l)\tau(u+D)}{2}. \tag{10$'$}$$

Since the sign of the intercept of Eq.$(10)'$, $\frac{c^F-(1+\alpha-l)\tau(u+D)}{2}$, is indeterminate, when c^F is high but τ, u, D and $\underline{I}$ are low then the reaction curve of firm F lies on upper part of Figure 3, and the corresponding equilibrium is plausible as point A and B. When c^F is low but τ, u, D and $\underline{I}$ are high, however the reaction curve of firm F lies on lower part, the corresponding equilibrium cannot be practical as point C.[6]

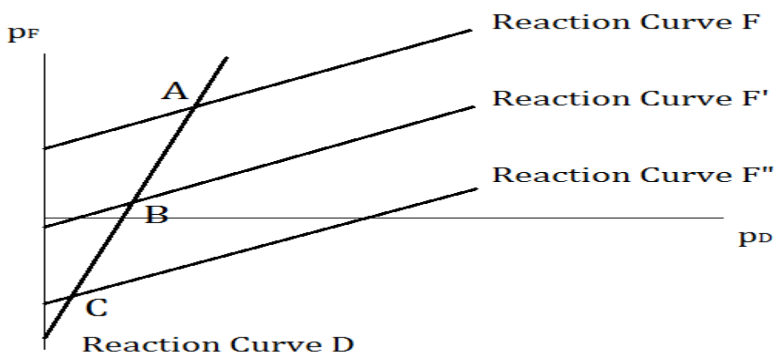

FIGURE 3 Plausible Bertrand Equilibrium Prices

ANNOTATION: In FIGURE 3, Reaction Curve D represents the reaction curve of firm D. Reaction Curve F, F' and F'' are also respectively, reaction curves of firm F. Specifically, Reaction Curve F has positive intercept; Reaction Curve F' has negative intercept but its absolute value is small; Reaction Curve F'' also has negative intercept and its absolute value is large. Therefore point A, B and C represent the Bertrand equilibrium for each case.

The latter case is consistent with our previously mentioned statement in footnote 5 that the economy where the lowest income is enough high does not import the foreign foods that may cause the health damage. Figure 3 implies that, in the economy in which domestic income level and the value or quality of foods are sufficiently high, the high-risk food is priced at a negative value and never divided.

The prices at the equilibrium derived in this Bertrand competition are as follows,

$$p^{D*} = \frac{(1 + \alpha + l)\tau(u + D) + 2c^D + c^F}{3}, \tag{11}$$

$$p^{F*} = \frac{(-1 - \alpha + 2l)\tau(u + D) + c^D + 2c^F}{3}. \tag{12}$$

Because of the relationship, $\theta = \frac{L}{l}$, when the distribution of income l is given and constant, the fluctuation in θ immediately means the fluctuation in the population, L. Now we realize that the fluctuation in θ cannot affect the equilibrium prices. That means *the population growth which does not change the income distribution and income level of the economy does not cause food price hikes*. This is because the firms' concern is how people are distributed *over their incomes* than how many people there are.

Ⅲ. The Comparative Statics

Before anything else, since the highest and the lowest income are respectively $(1+\alpha)$ and $\underline{I} = 1 + \alpha - l$, a rise in α means a rise in the economy wide income level, in turn, a rise in l means an increase in the population in low-income bracket under constant level of the highest income and the number of people in each point over the income, that is to say, a population growth which expands income gap.

Through the comparative statics analysis about the equilibrium, we obtain the following results with respect to the extent of income difference and the economy-wide income level.

$$\frac{dp^{D*}}{dl} = \frac{\tau(u+D)}{3} > 0, \qquad \frac{dp^{F*}}{dl} = \frac{2\tau(u+D)}{3} > 0,$$
$$\frac{dp^{D*}}{d\alpha} = \frac{\tau(u+D)}{3} > 0, \qquad \frac{dp^{F*}}{d\alpha} = \frac{-\tau(u+D)}{3} < 0.$$

Although the results with respect to an economic growth are plausible, we note that

$$\frac{dp^{F*}}{dl} > \frac{dp^{D*}}{dl} > 0, \tag{13}$$

holds. Subsequently we find out the following theorem.

Theorem 1

i) A population growth that is inclined towards low-income bracket and expands income difference raises not only price of domestic foods but also price of imported foods that may be unsafe.

ii) The extent of rise in price of low-priced imported foods is larger than that of domestic foods, for the effects caused by a population growth inclined towards low-income bracket and expands income difference.

iii) An economic growth raises price of domestic foods but lowers price of imported foods that may be unsafe.

Focusing on Eq.s$(9)'$-$(10)'$, we can explain that those phenomena occur because firm F raises its price voluntarily and that makes firm D rise its price to win the Bertrand competition, when the population in low-income bracket grows. And this is the reason why Theorem 1 *ii)* holds. Taking account of Theorem 1 and the result which we already obtained: the population growth without fluctuations of income distribution and economic growth never cause food price hikes, we notice that all kinds of population growth do not necessarily give rise to some food price hikes, but an impoverishment of the economy is the source of price hike of the problematic foods and aggravates the whole food price hikes.

Next, the results with respect to the public contamination rate, the value of foods and the health damage are as follows.[7]

$$\frac{dp^{D*}}{d\tau}=\frac{(1+\alpha+l)(u+D)}{3}>0,\qquad \frac{dp^{F*}}{d\tau}=\frac{\left(1+\alpha-2\underline{I}\right)(u+D)}{3},$$
$$\frac{dp^{D*}}{du}=\frac{(1+\alpha+l)\tau}{3}>0,\qquad \frac{dp^{F*}}{du}=\frac{\left(1+\alpha-2\underline{I}\right)\tau}{3},$$
$$\frac{dp^{D*}}{dD}=\frac{(1+\alpha+l)\tau}{3}>0,\qquad \frac{dp^{F*}}{dD}=\frac{\left(1+\alpha-2\underline{I}\right)\tau}{3}.$$

Accordingly, the economy where $\left(1+\alpha-2\underline{I}\right)>0\Leftrightarrow(1+\alpha)>2\underline{I}\left(\left(1+\alpha-2\underline{I}\right)<0\Leftrightarrow(1+\alpha)<2\underline{I}\right)$ holds is the economy with a large(small) income difference and a strong(week) bias. Concerning this, we realize a partly counterintuitive situation.

Theorem 2

In the economy where there exist a large income difference and a strong bias which satisfies the condition, $\left(1+\alpha-2\underline{I}\right)>0\Leftrightarrow(1+\alpha)>2\underline{I}$, *the results that* $\frac{dp^{F*}}{d\tau}>0$,

$\frac{dp^{F*}}{du} > 0$, $\frac{dp^{F*}}{dD} > 0$ *occur.*

Theorem 2 implies that a rise in the relative attraction of the domestic foods may raise not only the price of domestic foods but also the price of problematic imported foods, in the economy that possesses strong bias. Making use of firms' first order conditions to analyze this theorem, we suggest that a rise in τ and/or D(worsening in the quality control of the imported foods) can make its price either higher or lower, because such a worsening brings forth two effects: a direct effect which makes the price of imported foods decrease since consumers become to hesitate to demand the imported foods, and an indirect effect of price hikes that firm F rises its price to follow firm D's price setting to win the competition.[8)] Therefore, those effects mean, in the economy which has strong bias, the effect of the market competition(food price hikes) is more influential than the effect of risk cognition of consumers. Consequently, Theorem 2 implies that the large income difference should be reformed, because the large bias caused by the income difference makes the quality aggravation connected with price hikes, with respect to the imported problematic foods.[9)]

Ⅳ. Demands in the Equilibrium and Comparative Statics

Next, our substituting the equilibrium prices into Eqs.(7)-(8), the demands in the equilibrium can be derived as follows.

$$X^{D*} = \theta\left[\frac{(1+\alpha)+l}{3} - \frac{c^D - c^F}{\tau(u+D)}\right], \tag{14}$$

$$X^{F*} = \theta\left[\frac{-(1+\alpha)+2l}{3} + \frac{c^D - c^F}{\tau(u+D)}\right]. \tag{15}$$

Implementing comparative statics to the equilibrium demands, we obtain the results with respect to the extent of income difference and the economy-wide income level.

$$\frac{dX^{D*}}{dl} = \frac{\theta}{3} > 0, \quad \frac{dX^{F*}}{dl} = \frac{2\theta}{3} > 0, \quad \frac{dX^{D*}}{d\alpha} = \frac{\theta}{3} > 0, \quad \frac{dX^{F*}}{d\alpha} = \frac{-\theta}{3} < 0.$$

Concerning those results, we can exhibit that

$$\frac{dX^{F*}}{dl} > \frac{dX^{D*}}{dl} > 0, \tag{16}$$

holds. Thus we obtain the following theorem.

Theorem 3

i) A population growth that is inclined towards low-income bracket and expands income difference increases not only demand for domestic foods but also demand for imported foods.

ii) The extent of demand expansion of low-priced imported foods is larger than that of domestic foods, for the effects caused by a population growth inclined towards low-income bracket and expands income difference.

iii) An economic growth increases demand for domestic foods but decreases demand for imported foods that may be unsafe.

Note that Eq.(14) (or (15)) is composed of Eq.(7) and Eq.(11) (or Eq.(8) and Eq.(12)). Making use of inequality (13), we can argue that $\frac{dX^{D*}}{dl} > 0$ holds since there is no direct effect and the extent of increase in X^{D*} due to rise in p^{F*} is larger than that of decrease in X^{D*} due to rise in p^{D*}. Likewise, $\frac{dX^{F*}}{dl} > 0$ holds since there is a positive direct effect and it exceeds the negative indirect effects on the demand through price changes.[10] Since the price hike of problematic imported foods makes some consumers switch the choice from the imported to the domestic, the income of consumers beneath the threshold cared about by the government moves down. In other words, Theorem 3 implies that some consumers who have somewhat low income actually become to access the safe foods, due to the population growth with impoverishment of the economy.

Finally, the results with respect to the public contamination rate, the value of foods and the health damage are as follows.

$$\frac{dX^{D*}}{d\tau} = \frac{\theta(c^D - c^F)}{3\tau^2(u+D)} > 0, \qquad \frac{dX^{F*}}{d\tau} = -\frac{\theta(c^D - c^F)}{3\tau^2(u+D)} < 0,$$
$$\frac{dX^{D*}}{du} = \frac{\theta(c^D - c^F)}{3\tau(u+D)^2} > 0, \qquad \frac{dX^{F*}}{du} = -\frac{\theta(c^D - c^F)}{3\tau(u+D)^2} < 0,$$
$$\frac{dX^{D*}}{dD} = \frac{\theta(c^D - c^F)}{3\tau(u+D)^2} > 0, \qquad \frac{dX^{F*}}{dD} = -\frac{\theta(c^D - c^F)}{3\tau(u+D)^2} < 0.$$

Although so far we did not set any assumption about the cost functions, it is plausible to assume $c^D > c^F$, and owe the above signs to this assumption. Thus the following theorem is applied to the general economies where $c^D > c^F$ holds.

Theorem 4

Consider the economy where the production cost of the domestic firm exceeds that of the foreign firm. As the value of foods themselves as quality rises, demand for safe domestic *foods increases and demand for imported foods, foods may cause the health damage, decreases.*

Decomposing $\frac{dX^{D*}}{du}$ into direct and indirect effects, and utilizing results of comparative statics about the equilibrium prices, we imply that the positive direct effect on X^{D*}, $\frac{\theta}{\tau(u+D)^2}(p^{D*} - p^{F*})$ and the negative direct effect on X^{F*}, $\frac{-\theta}{\tau(u+D)^2}(p^{D*} - p^{F*})$ would play significant roles to above results. And Theorem 4 suggests a policy implication that if we can improve the quality of foods, we can mitigate the problem that low-income consumers tend to choose the foods that may cause the health damage and suffer that.[11)]

Ⅴ. Concluding Remarks

In this study, we have focused on the link between personal income level of consumers and the level of their concern with respect to food safety, introducing the model to express the biased preference towards food safety. In the model, thereby the low-income bracket tends to eat the low-priced problematic foods and may suffer the health damage, especially in the poorest economies that possesses large population and underestimations against the risk, or economies that has a wide income difference. Taking account of the population growth and economic growth, we analyzed the fluctuation of food price and the decision-making of consumers.

Through our theoretical analysis, although there are several ways of the population growth, as the nature of the economy we finally have found out that the population growth with an impoverishment is one source of price hike of the problematic imported foods and aggravates the whole food price hikes. Conversely, the results also suggest that the population growth without fluctuation of income distribution and economic growth cannot give rise to any price hikes. In addition, the simple economic growth with no population growth decreases the price of problematic foods. By those results, what positively correlates population growth to price hike of problematic foods is presumed as the impoverishment of the economy. As the policy implication, therefore those results will advocate that the large income difference should be reformed to avoid food price hikes and sustain the nutrition and hygiene.

This policy implication is reinforced by Theorem 2 that shows the large bias caused by the large income difference makes the worsening of quality control of the imported problematic foods connected with its price hike. In other words, the large bias causes counterintuitive and undesirable phenomena. However, one question that remains unanswered against this policy implication is that some consumers who have somewhat low income actually become to access the safe foods due to the population growth with impoverishment. Does such a policy suffer those consumers?

For this respect, Theorem 3 implies another policy implication: improvement of foods' qualities mitigates the consumption of the problematic foods by low-income bracket. Viewed from the opposite side, when the price competition in food industry harms quality of foods, it may also deteriorate the problem of health damages, but this is avoidable by causing the food firms to improve their qualities.

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1) In April 2013, those price levels had doubled or tripled in the rough compared to autumn of 2006. In August 2013, this tendency almost unchanged and they preserved 1.7~2.5 times, compared with autumn of 2006.

2) It is also forecasted that the increase in Asian population would turn to its decrease in around

2050.

3) Showing 2008 data, based on population subgroups stratified by family income, race and so on, from the National Health Interview Survey(NHIS), Cawley and Ruhm (2011) displayed the empirical evidence of existence of disparities in health behaviors across subgroups.

4) In turn, we can implicitly assume that $\tau(1+\beta)=1$ holds, as to an income that satisfies $I_i = 1+\beta$ but $\beta > 0$. We can suggest that the consumer who has income above $1+\beta$ doesn't regard any imported foods as foods since imported foods might cause the health damages.

5) We can insist that in the economy where the lowest income is high and which satisfies $\frac{p^D-p^F}{\tau(u+D)} < \underline{I}$, import cannot occur even if $p^D > p^F$ holds. So we focus on the former case hereafter.

6) We here exclude the case of implausible equilibrium, and also there is a possibility that we already excluded such a case by assumption that we put before.

7) $\frac{dp^{F*}}{d\tau} = \frac{(-1-\alpha+2l)(u+D)}{3} = \frac{(l-\underline{I})(u+D)}{3} = \frac{(1+\alpha-2\underline{I})(u+D)}{3}$ exists behind this explanation.

8) Although the price of domestic foods is also affected by indirect effect to win the competition to decrease its price, in the Bertrand equilibrium, the price of domestic foods always rises when such a worsening occurs.

9) The results of comparative static analysis with respect to production costs are below and those are plausible: $\frac{dp^{D*}}{dc^D} = \frac{2}{3} > 0, \frac{dp^{F*}}{dc^D} = \frac{1}{3} > 0, \frac{dp^{D*}}{dc^F} = \frac{1}{3} > 0, \frac{dp^{F*}}{dc^F} = \frac{2}{3} > 0.$

10) This indirect effect is decomposed into decrease in X^{F*} due to rise in p^{F*} and increase in X^{F*} due to rise in p^{D*}.

11) The results of comparative statics with respect to the production costs and the population growth without the fluctuation of the income distribution and economic growth are below and plausible:

$\frac{dX^{D*}}{dc^D} = \frac{-\theta}{3\tau(u+D)} < 0$, $\frac{dX^{F*}}{dc^D} = \frac{\theta}{3\tau(u+D)} > 0$, $\frac{dX^{D*}}{dc^F} = \frac{\theta}{3\tau(u+D)} > 0$, $\frac{dX^{F*}}{dc^F} = \frac{-\theta}{3\tau(u+D)} < 0$, $\frac{dX^{D*}}{d\theta} = (1+\alpha) - \frac{p^{D*}-p^{F*}}{\tau(u+D)} > 0$, $\frac{dX^{F*}}{d\theta} = \frac{p^{D*}-p^{F*}}{\tau(u+D)} - (1+\alpha-l) > 0$.

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Web Resources

Ministry of Agriculture, Forestry and Fisheries, Japan, http://www.maff.go.jp/e/index.html

National Health Interview Survey, http://www.cdc.gov/nchs/nhis.htm