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International price competition among food industries: The role of income, population and biased consumer preference

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ABSTRACT

The poor's sensitivity to prices means that a hike in food prices, as a burden on consumers, hinders the adequate supply of inexpensive food and worsens food safety problems caused by low-priced food. This paper theoretically studies the impact of economic growth with demographic transitions and food safety on food prices, providing a background for policies to protect consumers.

The results imply that the sources of food price hikes are (a) *Economic Growth*; (b) *Population Growth Accompanied by an Expansion in the Income Gap*; (c) *Remarkable Population Growth in the Past*; and (d) *Deterioration in the Safety of Foods Made in the South*. In the North, (d) is the most important factor; besides, (a) and (b) 'in the South' would affect global food prices, while food price hikes are inseparable from economic advancement in the South. Accordingly, guaranteeing the food safety of Southern foods leads to stable food prices in the North, whereas as long as economic advancement in the South continues, encouraging policies that artificially promote stable food prices and ensure food safety will be needed for both developing and developed countries.

1. Introduction

Since 2006, the international price of grain has clearly been trending higher compared to the period between 1970 and 2006.[1] What causes international food prices to become higher and unstable? Due to this change, academic research exploring the source of food price hikes has begun in earnest. Baek and Koo (2014) empirically found that the exchange rate is a significant factor influencing U.S. food prices. Yu (2014) also empirically found that food prices tend to decline in response to monetary expansion in China. In general, the source of this type of a price hike is considered to be, for example, abnormal weather conditions caused by environmental pollution in food exporting countries, a sudden rise in energy prices and rapid growth in the global population.

If we examine food price hikes from a slightly different angle, it is worth analysing how the recent global population movements and the expansion of the income gap have affected food prices, hand in hand with economic advancement. In 2011, the United Nations Population Fund forecasts that by the end of the century, the world population would exceed 100 billion and that the African population would increase threefold to approximately 36 billion, while the Asian population would continue to increase until 2050, and thereafter decrease.[2] In various countries, the rise in the population of those in poverty has also become a serious problem in recent decades. Hence, taking account of theories related to demographic transition that express how economic growth influences the population, such as those promulgated by Stolnity (1964), Leibenstein (1974), Becker (1960), and so on, we develop demand functions affected by changes in the social structure and incorporate those changes in an international Bertrand competition model for food industries, with the goal of capturing the price determination.

In a transitioning economy, the key issue is that soaring food prices force the poor to select low-priced food made in the South, although Southern food may involve faults with respect to its safety. Food price hikes are likely to hinder the adequate supply of low-priced food that nourishes the poor, together with possible health hazards. Hence, our model considers a food firm located in the North and a food firm located in the South and describes the market of a country where both risky food made in the South and safe food made in the North are provided. On this point, the most closely related research is that of Cardebat and Cassagnard (2010), who assumed Bertrand competition between the Northern and Southern firm and asymmetric information about the production process in the South, and analysed the exclusion of

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[1] See "Ministry of Agriculture, Forestry and Fisheries", http://www.maff.go.jp/e/index.html.

[2] See "The State of World Population 2011".

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problematic Southern goods by the Northern government. In Cardebat and Cassagnard (2010), however, Southern goods did not represent a possible health hazard. Calzolari and Immordino (2005) also investigated international trade in an innovative food subject to uncertain health effects, and described governments' decisions related to food safety through a learning process with its solution concept, the Perfect Bayesian Equilibrium. On the other hand, we owe the simple explanation of the food price hike under some risks to the Nash Equilibrium, as our model is not defined to analyse governments' decisions. Becchetti et al. (2014) theoretically investigated the conditions under which a firm switches from price competition to price and CSR (corporate social responsibility) competition in the market for organic food etc. Thus Becchetti et al.'s (2014) model has many points of resemblance to our model, but retained an interest in corporate behaviour.

What makes the problem of food safety more serious is consumer behaviour. In our model, consumers are distributed based on income, and lower income individuals are less sensitive to health damage. Examining the effect of income on behaviour in the context of choosing differently priced health care plans by low income families, Chan and Gruber (2010) already empirically insisted that higher income individuals were not more price sensitive and that those who selected the lowest cost plan were more price sensitive. Although Cawley and Ruhm (2011), who provided an overview of risky health behaviour, showed that income could either increase or decrease unhealthy behaviours, how income affects behaviour should depend on the situation, and our setting that income promotes health consciousness is considered as more appropriate.[3] Among the vigorous discussion on the bounded rationality, e.g., Herbert (1984), Gruber and Köszegi (2001) and many others, it is also important to note that McDermott et al. (2008) suggested that people could be harmed by their inherent preferences for certain foods, which would prove the existence of factors that divert our attention from food safety.

In Section 2, we define our model of income and population. In Section 3, we determine the demand functions and a game between food industries, completing and closing the model. With the full model in hand, Section 4 analyses the nature of food prices. Section 5 presents the conclusions, while the Appendix reports a detailed calculation process.

2. A model of population changes, food prices and food safety

We consider the world economy composed of North and South. Because income level and health awareness differ from person to person, it is natural to imagine that food products are differentiated and tailored. Hence, in the model, N-firm (a representative Northern firm) in the North produces N-food (North food), and S-firm (a representative Southern firm) in the South produces S-food (South food). Both types of food are provided for the world market and appear easily distinguishable from each other. The problem we set is that the consumption of S-food may cause health damage, but that there is a demand for S-food because its price is sufficiently low. Hence, we discuss at what levels the prices of these two types of food are determined in the food market according to how consumers react to health damages. First, we define the basic quality of food that is common to two types of food and the extent of health damage as q and D, which are to be given and constant.

2.1. Consumers and health awareness

Let us consider two levels of utility for consumers that depend on q, D and the personal income level of each consumer. Namely, the utility obtained from one unit of food is expressed as:

$$U(q,D;I_i) = U^1(q) + U^2(D;I_i) = \sqrt{q} + (-I_i)D = \begin{cases} \sqrt{q} & for\ safe\ food \\ -I_iD & for\ unsafe\ food \end{cases},$$

for the whole consumer. Here I_i denotes the personal income level of consumer i, and we suppose that all the N-food and $(1-m)$ percent of S-food are safe food with $q>0$ and $D=0$, while m percent of S-food is unsafe food with $D>0$ and $q=0$. As the comprehensive utility, $U(q,D;I_i)$, is measured by both $U^1(q)$ and $U^2(D;I_i)$, the concavity of $U^1(q)=\sqrt{q}$ implies that each consumer is risk averse as a whole and $U^2(D;I_i)=(-I_i)D$ expresses health awareness, which depends on personal income level and diminishes in proportion to the extent of an individual's poverty. That is, this formula of utility is based on the cardinal behaviour for food consumption: (i) when the value of health damage, D, is positive, the basic quality, q, no longer makes sense, (ii) behaviour related to food consumption is risk averse, and (iii) lower income individuals are less sensitive to health damage.

For consumer i with I_i, the difference between the utility and the price of the corresponding food gives two consumer surpluses:

$$CS^N = \sqrt{q} - p^N, \tag{1}$$

$$CS_i^S = (1-m)\sqrt{q} - mI_iD - p^S. \tag{2}$$

Here, p^j $(j=N,S)$ denotes the price of j-food. Comparing two levels of consumer surplus, consumer i chooses N-food or S-food and demands at most one j-food $(j=N,S)$. Next, we suppose that consumer i has an incentive to purchase a food if the consumer obtains a non-negative consumer surplus by purchasing that food:

$$CS^N \geq 0 \iff \sqrt{q} - p^N \geq 0, \tag{3}$$

$$CS_i^S \geq 0 \iff \frac{(1-m)\sqrt{q} - p^S}{mD} \geq I_i. \tag{4}$$

We also suppose that consumer i prefers and chooses the type of food that gives the consumer a higher consumer surplus. Accordingly, the income level of marginal consumers is expressed as:

$$CS^N = CS_i^S \iff I_i = \frac{p^N - p^S - m\sqrt{q}}{mD}. \tag{5}$$

As to Eqs. (3)–(4), we note that both types of food are provided only after $\sqrt{q} \geq p^N$ and $\sqrt{q} \geq p^S$ are ensured. In addition if $p^N \leq p^S$ holds, not only would $CS^N > CS_i^S$ hold for the entire consumer but also, with regard to Eq. (5), $\frac{p^N - p^S - m\sqrt{q}}{mD}$ would be negative. Thus, to focus on the circumstance that both types of food are provided, we set

Condition 1 : $\sqrt{q} \geq p^N > p^S$.

Under Condition 1, all consumers can obtain a consumer surplus from N-food, while only the poor can obtain a consumer surplus from S-food. Lastly, $\frac{(1-m)\sqrt{q}-p^S}{mD} - \frac{p^N - p^S - m\sqrt{q}}{mD} = \frac{\sqrt{q}-p^N}{mD} > 0$ concludes that the income level where the incentive to purchase S-food vanishes is above the marginal income indicated by Eq. (5) as in Fig. 1. Consequently, we define the threshold of the demand as $I^{TD} \equiv \frac{p^N - p^S - m\sqrt{q}}{mD}$.

[3] Using 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) showed empirical evidence of the existence of disparities in health behaviours across subgroups.