DEVELOPMENT OF A CONSISTENT FOOD SECURITY INDEX FOR EARLY WARNING SYSTEMS*

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food security index, early warning system, agflation

Abstract
The objective of this study is to develop a food security index that is consistent with five principles: boundedness, reliability, duplicability, applicability, and predictability. The index developed, called National Food Security Index (NFSI), is easy to interpret and comparable across time and among countries. The NFSI is composed of three components, physical availability, economic affordability, and market accessibility, and can be calculated in terms of calories as well as quantity. The NFSI measures a country's capability of accessing the food it requires on a yearly basis. The index can be used to build early warning systems for individual countries.

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Ⅰ. Introduction

Since 2006, the global price inflation caused by soaring food prices has continued distressing the food importing countries and the people living in the countries. Over 20 countries have experienced riots caused by the skyrocketing prices of staple crops after 2008. The so-called agflation, which peaked in 2008, was reduced during the subsequent two years. However, it reemerged in 2010 owing to the poor harvest of wheat in Russia and in the Former Soviet Union countries. In 2012, the corn prices surged due to the drought and heat waves in the U.S. corn-belt area. FAO reported that the food prices in 2012 set a record high since 1990 when they began to calculate the food price index. The recent anti-government demonstrations in Tunisia and Egypt that toppled the dictatorship regimes were sparked by food shortages. The World Economic Forum held in Davos in January 2011 discussed food issues and the G20 summit meeting in November 2011 set food security as the key agenda.

There are many reasons for the agflation. Severe crop failures due to adverse climate change and the U.S. bio-fuel policy are regarded as the major causes. Additional factors include the population growth and increasing consumption of meat products in China and Asian developing countries. These reasons are not at all temporary and the high food price seems to become a chronic phenomenon. The world real food price has started increasing for the first time in over 50 years. Clearly, the food security of the poor around the world is endangered.

Solutions to the food insecurity problem require international cooperation as well as domestic efforts. Thus, we need to know how problematic the food security is in the country concerned and how the situation should be quantitatively measured. The measurement should incorporate the economic as well as the physical capabilities of the country to secure the required food. It should also reflect the world market circumstances which may inhibit procurement of food regardless of the country's ability to secure the needed food from the world market. The measurement should be straightforward in its interpretation and comparable among countries and over time.

The objective of this study is to develop a consistent measure of a food security situation in a country, that is, a food security index (FSI). The index should be consistent in the sense that it follows the principles that a desirable

FSI possesses. We propose five such principles in the text. The index we developed can not only measure the current situation, but also predict the situation in the future. Early-warning systems on food crisis and proper counter-measures can be developed based on the consistent measurement of the food security situation. To distinguish from other existing FSIs, we call the index developed in this study as the "National Food Security Index," or simply NFSI.

This paper consists of six chapters. The second chapter reviews the previous food security indices and suggests five general principles for rational food security indices. The third chapter explains the model for NFSI, followed by the fourth chapter presenting the estimated results for selected countries. The fifth chapter proposes how to use NFSI to set thresholds for early warning systems. The sixth chapter concludes with some remarks.

II. Review of Previous Models

Food security has been defined differently by institutions and researchers. On their web-site home page, the WHO explains food security as follows:

> The World Food Summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life." Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences.

FAO provides a similar definition:

> Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Both definitions commonly suggest three key-words for achieving food security: sufficiency, safety, and nutrition. Quantitative sufficiency is a reasonable and measurable concept. However, it seems rather difficult and complicated to measure the level of safety or nutritive conditions. Pinstrup-Andersen (2009) discussed several definitions of food security in the literature and asserted that food security is referred to as whether a country has access to enough food to meet the dietary energy requirement. This assertion seems a reasonable basis for an FSI.

Despite its importance, the concept of FSI has received limited attention from even academic circles. This is mainly because food security has never been endangered for a long period of time. The green revolution in the 1960's made the second half of the 20th century "age of affluent food." For the first time in human history, the world has enjoyed abundant food except for only a few sporadic years. In addition, most developed countries are food-exporting countries, and hence food security is not an important issue. They may even benefit from the world food crisis. Food crisis hurts lower income people in less developed countries in Asia and Africa the most. Food crisis also troubles wealthier Asian countries such as China, Japan, and Korea who are net food importers.

Only a few studies have suggested quantifiable FSIs. The UN's International Fund for Agricultural Development (IFAD) first developed (to our knowledge) an FSI, and Korea Rural Economic Institute (KREI) applied the IFAD's index to Korea (Sung et al. 2000). The index, however, has several flaws. IFAD's index is constructed as a weighted average of food consumption divided by variability of consumption and food production divided by production variability as in equation (1). The index considers physical demand and supply situations. However, its economic interpretation is not clear. The concept of food security should be related to the supply capability of needed food. This index can hardly serve as such an indicator.

$$FSI\ of\ IFAD = a\ (consumption/volatility\ of\ consumption) + (1-a)\ (production/volatility\ of\ production), \quad (1)$$

where a is the weight.

Lee (2009) with the Nonghyup Economic Research Institute (NHERI) in Korea extended the IFAD's index to reflect the international market structure of major crops. His model suggests estimating the oligopolistic power in the market. However, the estimates vary according to model, estimation method, and/or data used, resulting in different estimates for food security.

Park et al. (2011) with the Samsung Economic Research Institute (SERI) developed an index devoted to the full definition of food security. SERI's food security and safety index includes factors indicating two pillars: food security which consists of food availability and food accessibility, and food safety which consists of production sustainability, nutrition and environmental integrity. Twenty variables are used to construct the index. However, some of the variables must be estimated and others are never clearly defined. Those variables such as "agricultural R&D budget", "labor productivity", and "shares of GM crops imported" do not have clear implications for food security. Furthermore, their index seems to lack duplicability and, thus, inter-country comparisons are hardly possible.

In 2012, The Economist Intelligence Unit started providing a Global Food Security Index (GFSI), which consists of 50 indicators representing affordability, availability, and quality and safety measures. This index, however, suffers from the problems similar to those of the SERI index. Variables such as "public expenditure on agricultural R&D" and "agricultural infrastructure" cannot indicate the current food problem situation. A variable such as "access to financing for farmers," which measures the availability of financing to farmers from the government, does not seem immediately relevant to food security. Most of all, GFSI provides numbers from a black box, and hence, they are almost impossible to duplicate.

Existing FSIs tend to suffer from several drawbacks. Some simply do not include relevant variables for food security. But, most of them include such variables that are not relevant for indicating the current food situation or require estimations or judgments by researchers at the cost of transparency and duplicability.

However, the FSI should be easy to understand and straightforward in interpretation. It should also be duplicable such that anyone can get the same results. It should be comparable among countries and across time so that it can clearly indicate the seriousness of the current situation. Most of all, the index should be able to predict at least one year ahead so that it can serve as an alarm bell for future food crises.

Thus, we suggest five principles for a reasonable FSI to follow. First, the index should provide numbers that are bounded on [0, 1] so that it can be easily interpreted (boundedness). Second, it should be calculated with data from internationally accredited institutions so that the results are reliable (reliability). Third, the formula should be clear and duplicable (duplicability). Fourth, it should be easily applicable to any country of interest (applicability). Finally, an FSI should be predictable so that we can handle a situation of food insecurity before it leads to problems such as food riots[1] (predictability). This study develops an FSI that is consistent with these five principles.

III. The Model for National Food Security Index

As Pinstrup-Andersen (2009) asserts, there are many definitions of food security, each with a different meaning. Thus, we need a concrete definition of food security to develop a quantifiable index. We claim that a country is food secure in a given year if the country as a whole can meet physical demand for food from domestic supply (i.e., production plus inventory) or can economically afford the food needed irrespective of the outside market conditions. We do not fully consider the nutritional adequacy of food, because setting relevant and objective levels of nutrition for all people is too complex. To supplement, however, we calculate a calorie-based FSI in addition to a quantity-based FSI to incorporate the nutritional dimension of food security.

The quantity-based FSI is constructed for the four main staple crops: rice, wheat, corn, and soybeans. An FSI based on the quantity term is straightforward to interpret and easy to compute. By contrast, the calorie-based FSI incorporates calories from meat consumption as well as those from other food. Thus, it is more comprehensive compared to the quantity-based index that is applied only to the raw material cereals.

As shown in Figure 1, the NFSI is composed of three components: physical availability, economic affordability, and market accessibility.

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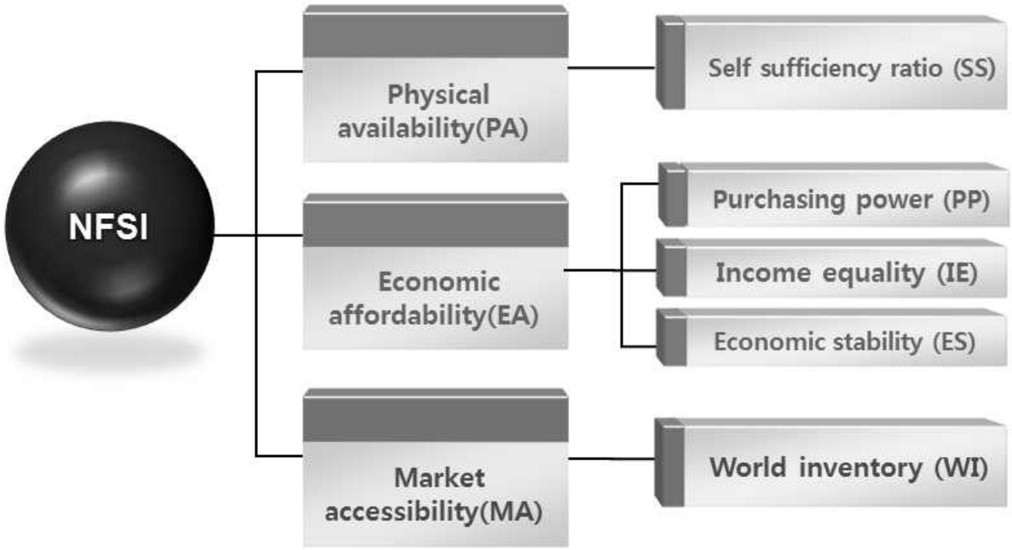
[1] Food crisis occurs if there is a shortage and/or unequal distribution of food. Causes of food crisis include unexpected sharp food price rises, harvest failures, incompetent food storage, transport problems, hoarding, poisoning of food, and/or attacks by pests. If the food crisis situation reaches a very critical stage, probability of triggering food riot is increased. In 2008 and 2011 a significant number of countries experienced food riots.

FIGURE 1. The Structure of NFSI



Physical availability (*PA*) indicates the ability of domestic production (S_i) and beginning stock (I_i) to meet the domestic consumption of crop *i* (D_i). This inventory-adjusted self-sufficiency ratio in terms of quantity (for the quantity based FSI) and in terms of calorie (for the calorie-based FSI) as shown in equation (2), are used to represent the physical capability of domestic supply to meet demand. Most countries have a *PA* bounded on [0, 1]. However, some food-exporting countries may have a ratio higher than 1. In that case, PA_i is treated as 1 for the boundedness principle. However, it does not seem too restrictive because food supply equal to the domestic demand in a given year is as sufficient as food supply higher than domestic demand in terms of food security.[2]

$$PA_i = (S_i + I_i) / D_i \qquad (2)$$

[2] An anonymous referee points out that it is not logical to treat the countries with the self-sufficiency ratio higher than 1 equally as the countries with the self-sufficiency ratio equal to 1. We nonetheless keep this truncation because if otherwise the self-sufficiency ratio higher than 1 will over-estimate the contribution of the physical availability compared to other indicators.

Economic affordability (*EA*) comprises three factors. The first factor is purchasing power (*PP*) that shows whether the national income is large enough to afford the cost of the required food. We use 1 minus the Engel coefficient, which is the household expenditure on food divided by GDP, as in equation (3a). The Engel coefficient that indicates the proportion of food expenses on expenditure is negatively correlated with the food security. If a country spends all of its income on food, the value of PP becomes 0. By contrast, if a country has extremely high income compared to food expenditure, the PP is close to 1. The consumption of alcoholic beverages is excluded while that on food-away-from home is included in the Engel coefficient. This will reduce the effect of differences in consumption patterns among countries due to the changes in lifestyle.

$$PP = 1 - Engel\ Coefficient \qquad (3a)$$

The second factor is income equality *(IE)*. Even if a country as a whole has sufficient income for food, there may be poor people who cannot afford the needed food. The GINI index is usually used to represent such income inequality. We use 1 minus the GINI index, and hence, a lower GINI index indicates higher food security, as shown in equation (3b). If the income is perfectly equally distributed in a country, the GINI index is 0 and the value of IE is 1. If the opposite is the case, the index is 1 and the IE value is 0.

$$IE = 1 - GINI\ Index \qquad (3b)$$

The third factor is the economic stability *(ES)* of the nation as a whole. If the economy is unstable and fragile to macroeconomic shocks, it should pay more to purchase food from the world market because of higher exchange rates and/or higher costs for credit. We use Moody’s sovereign credit ratings for the indicator as shown in (3c). Moody’s ratings are used because the company’s governance is known to be well-diversified compared to other credit rating agencies. Moody's evaluates the credit-worthiness of 115 countries in 2012, which outnumbers S&P (60 countries) or Pitch (89 countries). The ratings are divided into 20 levels, and the highest level (Aaa) is given a value of 1. The value decreases by 0.05 for each rating, and the lowest level gets a value of 0. Ca and C indicate the condition in and near default, respectively, and both are given 0.[3]

$$ES = Moody's\ Score \tag{3c}$$

Market accessibility reflects the international market conditions (MA_i). Even if a country can afford the food it requires, a tight world market may hinder the country from purchasing the food. In 2009, when a severe food shortage prevailed, many countries embargoed food exports for their own domestic consumption. In some cases, they embargoed against certain countries for political reasons. For the market condition, we use the current level of the world stock (WI) divided by the appropriate level of stock, as shown in equation (4). FAO suggests having a stock level covering the consumption for two months (WC2) for food safety. If the current stock is equal to the consumption for two months MA_i is 1. If it is lower, it is less than 1. The number can be higher than 1, which indicates that the market has little trouble to supply food demanded with money. In this case, it is truncated by 1 for boundedness.[4]

$$MA_i = WI_i \ / \ WC2_i \tag{4}$$

To compute the NFSI by commodity, we multiply the three components: physical, economic, and market components, as in equation (5). They are multiplied to allow for interactive effects. That is, the marginal effect of one component is not independent of the other two, and all the three components are necessary for achieving food security. The physical and market components are crop-specific, and they are subscripted using i, indicating a specific crop. In contrast, the economic component is identical across commodities, and no subscript is needed.

EA is specified as the average of the three sub-indicators: PP, IE, and ES. The average is used instead of the multiplicative form because the marginal effect of a sub-indicator on EA is likely to be independent of the other

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3 Appendix table 1 shows the converted Moody's rates into the scores of economic stability.

4 This truncation implies that this indicator can be interpreted as a penalty given to the situation where the world market is in short of the proper level of inventory. The penalty is applied to all nations commonly.

sub-indicators.

$$Commodity\ NFSI_i = PA_i * EA * MA_i \quad (5)$$
$$where,\ EA = (PP + IE + ES)/3$$

The aggregate NFSI for the country of interest is specified as the weighted average of the commodity NFSI, as in equation (6). The weight is the value of supplied divided by the total value supplied. Instead of the demand, which is more relevant for food security, the supply is used simply because of data availability.

$$Aggregate\ NFSI = \sum i\ w_i * NFSI_i \quad (6)$$

where, $$W_i = \frac{value\ of\ grain\ i\ supplied}{total\ value\ of\ grain\ i\ supplied\ anually} = \frac{(G_i \times Q_i)}{\sum_{i=1}^{n}(G_i \times Q_i)}$$

$$G_i = price\ of\ grain\ i\ and\ Q_i = annual\ supply\ of\ grain\ i$$

The calorie-based NFSI is an aggregate measure of all food items. Thus, it is calculated as in equation (7):

$$Calorie\ NFSI = PC * EA * MA \quad (7)$$

where PC is the country's inventory-adjusted self-sufficiency ratio in terms of calories and MA is the ratio of the food stock to the world consumption for two months. For MA, we average the stock-to-consumption ratio for all commodities listed in the Foreign Agricultural Services (FAS) of the USDA database and divide it by 16.6%, which is the recommended level of stock by FAO (i.e., for two months). Note that there is no subscript for a specific crop, because it is the aggregate measure. EA is the same as in equation (5).

The NFSI developed above is straightforward and easy to understand. The food security of a country is regarded as sound if the NFSI approaches 1 and is in great danger if the NFSI nears 0. The NFSI is transparent, and duplicable, and reliable. It is standardized such that the food security situation can be compared among countries and across time. Using predicted values for domestic and international production and stock data, the NFSI can be forecasted, and hence, early warning systems can be developed based on the index.

IV. Data and Estimated Results of NFSI

For the inventory-adjusted self-sufficiency ratio, we use the data for production, consumption, and beginning stock from the USDA's *Grain World Markets and Trade and World Agricultural Supply and Demand Estimates*. The data for the Engel coefficients are obtained from the National Bureau of Statistics of each country. The GINI index for income inequality are obtained from the *International Statistical Yearbook* by the National Bureau of Statistics in Korea.

The Moody’s scores for economic credibility are from the Research & Rating report by Moody's. The data for stock and consumption are from the Economic Research Service of the USDA Yearbook. The grain prices are from the *International Commodity Prices* by the FAO. The data for the calorie self-sufficiency ratios are from FAO’s *Custom Query*. The data period starts from 2000, for which data are available for the most countries. A total of 24 countries, for which data are available, are analyzed in this study.

Figure 2 shows the NFSI for each major commodity and the aggregate measures for Korea.[5] The number predicted for 2013 is developed from the predicted values for production, consumption, and stock data by the USDA. The NFSI was 0.55 in 2000 and hit the highest level of 0.60 in 2005. Since then, it has decreased with agflation and reached the lowest level of 0.51 in 2011. In 2013 it is expected to be 0.52. The world market situation (Mi) dominates Korea’s food security because other components are relatively stable. This indicates that the food security in Korea is very sensitive to the outside market shocks and is in potential danger because its self-sufficiency ratio has been lower than 25% in recent years.

Figure 2 shows that the average aggregate NFSI in Korea is 0.56, and it is much lower without rice. The average NFSI for rice is approximately 0.71, while those for the other crops are less than 0.20. The food security in Korea is very fragile and unbalanced. Without rice, Korea may face an immediate food crisis.

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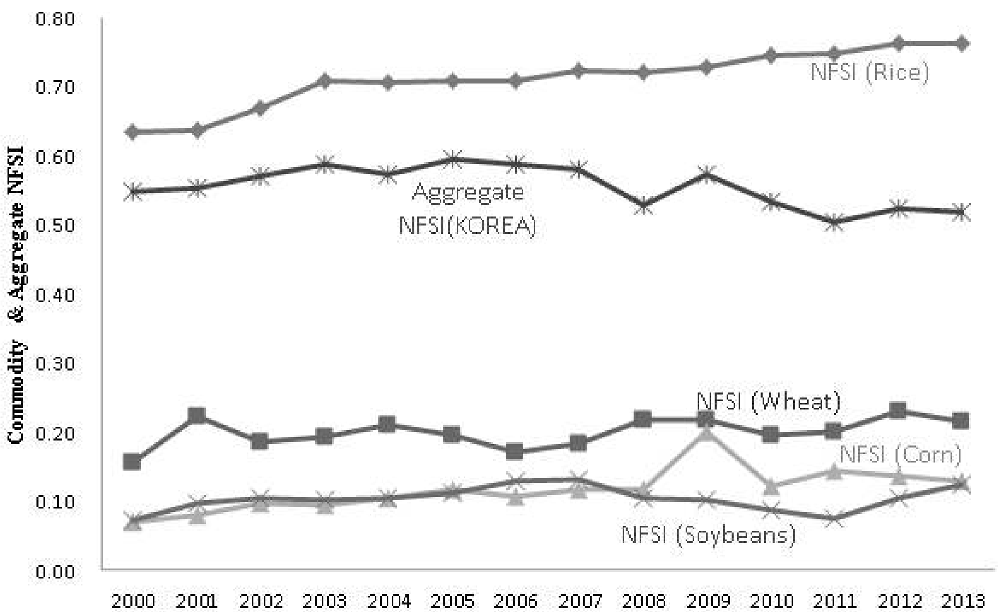
[5] Appendix figure 1 and 2 show specific indicators for rice and corn, respectively.

FIGURE 2. Commodity and Aggregate NFSI: Korea



In Figure 3, the aggregate NFSIs of the three largest food-importing countries in Asia are compared with that of the United States, the largest food-exporting country. All three importing countries show decreasing NFSIs. The most food-secured country is Japan, with average NFSI of 0.64 during 2000-2013. However, it is much lower than that of the U.S. The average NFSI for the U.S. during the same period is 0.80, with a standard deviation of 0.04. As expected, the U.S. is very secure in food. However, the index was lowered sharply in 2010 mainly because of the worsened income distribution caused by the financial crisis that originated in the U.S. and the reduced world stock of major crops.

Even if individual differences exist among countries, the estimated NFSIs of most countries show a downward trend due mainly to the deterioration of international stock of corn since 2010. The NFSIs of Japan and South Korea in 2007 and 2008 declined, while those of the United States and China showed little change. In Japan, the self-sufficiency ratio of wheat decreased due to the decline in production and inventory in 2007. In the case of Korea, because of the steadily decreasing production of soybeans in 2007 and 2008 the self-sufficiency ratio and the NFSI of soybeans decreased. China, the most populous country in the world, seems fragile in food security, which may cause a critical global problem.

FIGURE 3. Aggregate NFSI of selected countries: 2000-2013

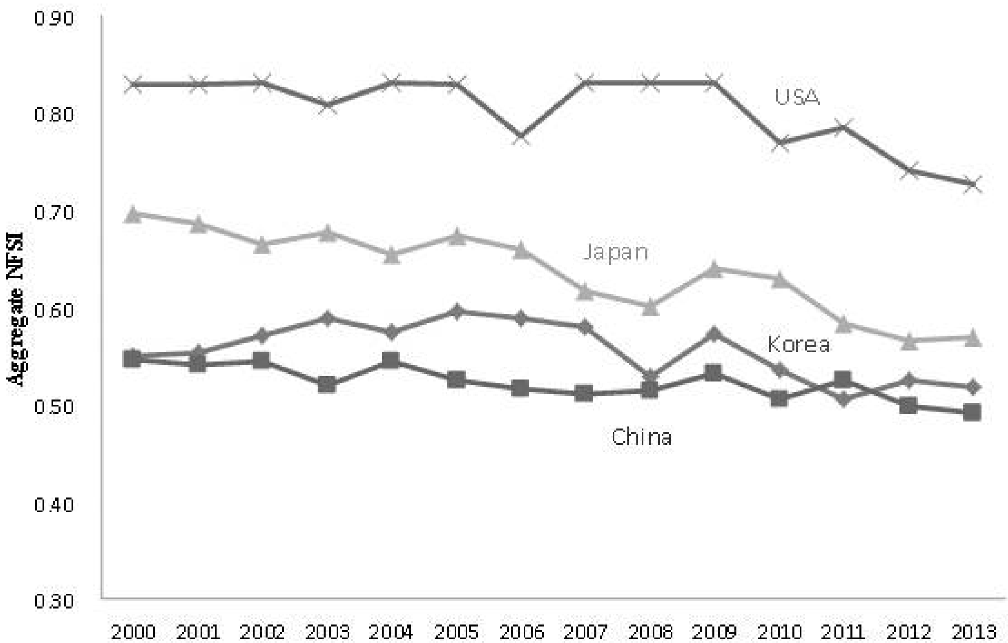
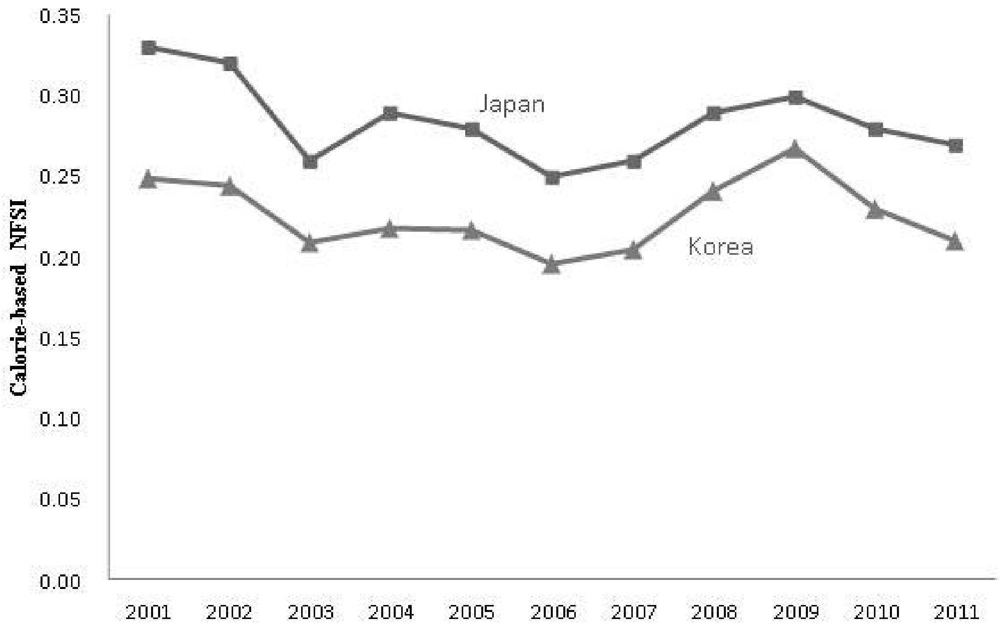


Figure 4 shows the calorie-based NFSI of Japan and Korea for which the data for the self-sufficiency ratio in terms of calories are available. Despite a higher self-sufficiency ratio, the calorie-based indices are much lower than the quantity-based ones mainly because of the lower world market stock ratio. The Calorie-based NFSI increased to 0.30 in Japan and 0.27 in Korea in 2009. This is due mainly to the steadily increasing inventory since 2006, which raised the MA from 0.77 in 2006 to 0.92 in 2009. Korea shows a larger increase because of the increased self-sufficiency ratio in calories (PA) from 0.36 to 0.40. Because the calorie-based NFSI represents a country's overall and ultimate food security, the countries need to act immediately for strengthening the food security.

FIGURE 4. Calorie-based NFSI of Korea and Japan



V. NFSI and Early Warning Systems[6]

The NFSI can be used to develop early warning systems. For this, we need to determine the thresholds of NFSI below which food security is endangered. We first conduct a diagnostic test to determine whether the NFSI is capable of indicating food crisis. The binary variable for the food riots (FRIOT) that occurred during 2006-2008 is regressed against the NFSI and Internal Conflict (IC) index developed by the Political Risk Group, as shown in equation (8). The IC indicates the domestic political stability of a country. It ranges from 0

6 Early warning systems are mainly developed in the field of finance sectors. In agricultural sectors, Kim and Seung (2009) developed the complex leading index using the signal approach, which is used to alarm a sharp increase in world grain prices. Since this index only focuses on changes in grain prices, it can hardly serve as an alarm bell of overall food security situation.

(unstable) to 12 (stable) and is composed of 4 points for civil war or coup threat, 4 points for terrorism or political violence, and 4 points for civil disorder. IC is included in the model because food crisis should be aggravated with political instability. The interaction of the two variables is included to capture the joint effect of food security and political stability on food riots.

$$FRIOT_{it} = a_1 + a_2 NFSI_{it} + a_3 IC_{it} + a_4(NFSI_{it} * IC_{it}) + \delta_i + \varepsilon_{it} \quad (8)$$

where αs are parameters and δ is the country dummy variable for panel data estimation. The subscript *i* indicates the country and *t* indicates the year from 2006 to 2008.

Table 1 shows the estimated results. All variables are statistically significant within the 5% confidence level. The marginal effect of NFSI is -2.90IC+25.98, which indicates that when IC is less than 8, a lower NFSI increases the probability of a food riot. The marginal effect of IC is -2.90NFSI+0.68, which indicates that when NFSI is less than 0.23, a lower IC increases the probability of a food riot.

TABLE 1. Estimated Results for Food Riots

Independent Variable	Coefficient (Std. Error)
C	-7.4467** (3.0014)
NFSI	25.9783** (10.3852)
IC	0.6814** (0.3297)
IC_NFSI	-2.9012*** (1.1222)
# of observations	240
McFadden R^2	0.1348

Note : Figures in parentheses are standard errors.
*** and ** represent statistical significance at the 1% and 5% levels, respectively.

To determine the threshold levels for early warning systems, we conducted a cluster analysis based on NFSI and IC for the 24 sample countries. We identified three clusters from the analysis. The first cluster, composing six countries (China, France, Japan, Korea, the U.S., and Vietnam) has a mean NFSI of 0.64 with a minimum of 0.48 and a maximum of 0.83. This group experienced no food riots during the sample period (2002-2011) and is regarded as food secure. The second cluster, composed of eleven countries (Bangladesh, Egypt, Greece, India, Indonesia, Mexico, Morocco, Pakistan, Philippines, Spain, and Tunisia) has a mean of 0.42 with a minimum of 0.23 and a maximum of 0.52. Ten out of the eleven countries experienced food riots and are regarded as food-insecure. The third cluster, composed of seven countries (Algeria, Angola, Cameroon, Jordan, Mozambique, Uganda and Iraq) has a mean of 0.21 with a minimum of 0.02 and a maximum of 0.50. These seven countries also experienced food riots. This group seems to be identified separately from the second cluster because of low IC, and can be regarded as countries having immediate food crisis.

TABLE 2. Summary Statistics of Cluster Analysis

	Summary statistics		
	Cluster 1	Cluster 2	Cluster 3
IC_max	11.5	11.0	10.5
IC_min	9.0	5.5	2.5
IC_mean	10.1	8.3	8.1
NFSI_max	0.83	0.56	0.50
NFSI_min	0.48	0.23	0.02
NFSI_mean	0.64	0.42	0.21
# of countries in the cluster	6	11	7
# of countries with food riots	0	10	7

Notes 1) A panel data of 20 countries from 2002 to 2011 are used.
2) SPSS 18.0 is used for analysis using hierarchical clustering.

Based on the analysis, we suggest a three-tier early warning system. The first tier is the green level, which indicates an NFSI higher than 0.5. The countries in this tier are relatively food secure and have a low chance of food riots. The second tier is the yellow level, which indicates an NFSI lower than 0.5 but higher than 0.25. The countries in this tier are food-insecure and have a high chance of food riots, and hence, they need immediate actions to enhance food security and careful monitoring. The third tier is the red level, which indicates an NFSI lower than 0.25. The countries in this group are in a serious and immediate food crisis. There is a high chance of food riots, and these countries need fundamental and long-term actions to be food secure.

VI. Summary and Concluding Remarks

This study developed a food security index that is consistent with five principles: boundedness, reliability, duplicability, applicability, and predictability. The index is called NFSI, which is easy to interpret and is reliable. The NFSI is composed of three components: physical, economic, and market components. The NFSI is calculated in terms of quantity as well as calories term.

The NFSI is designed to measure a country's capability of accessing required food as a whole. The capability can be compared across time and with other countries. The index can also be used to build early warning systems for individual countries. However, the concrete and specific actions required to enhance the food security should vary across countries.

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APPENDIX

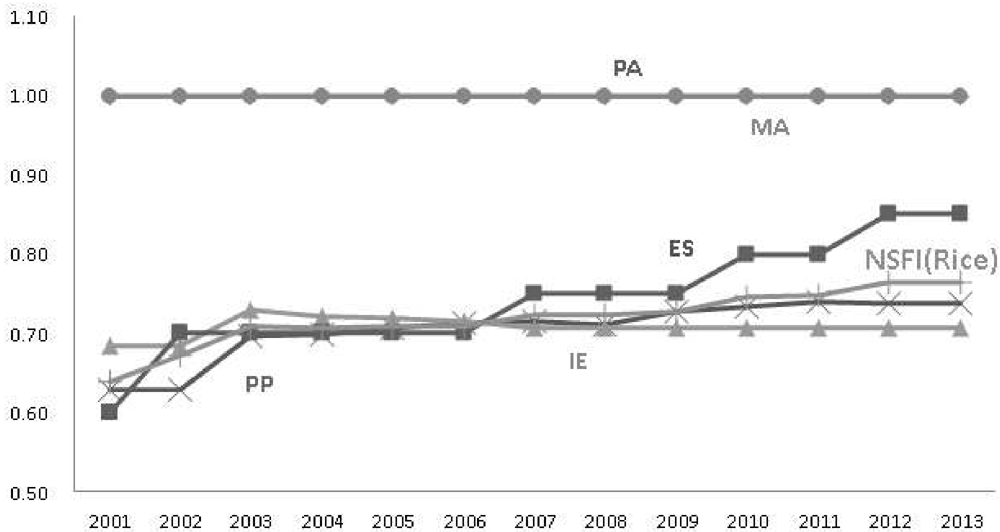
<Appendix Table 1> Converted Moody's Rates into Scores for Economic Stability

1	Aaa	1.00
2	Aa1	0.95
3	Aa2	0.90
4	Aa3	0.85
5	A1	0.80
6	A2	0.75
7	A3	0.70
8	Baa1	0.65
9	Baa2	0.60
10	Baa3	0.55
11	Ba1	0.50
12	Ba2	0.45
13	Ba3	0.40
14	B1	0.35
15	B2	0.30
16	B3	0.25
17	Caa1	0.20
18	Caa2	0.15
19	Caa3	0.10
20	Ca	0.05
21	C	0.00

<Appendix Table 2> Commodity NFSIs for Selected Countries: 2000-2013

	Korea					Japan				
year	NFSI (Rice)	NFSI (Wheat)	NFSI (Corn)	NFSI (Soybeans)	**NFSI (aggregate)**	NFSI (Rice)	NFSI (Wheat)	NFSI (Corn)	NFSI (Soybeans)	**NFSI (aggregate)**
2000	0.63	0.16	0.07	0.07	**0.55**	0.82	0.23	0.07	0.13	**0.70**
2001	0.64	0.22	0.08	0.10	**0.55**	0.82	0.22	0.06	0.15	**0.69**
2002	0.67	0.19	0.10	0.10	**0.57**	0.82	0.22	0.07	0.14	**0.66**
2003	0.71	0.19	0.09	0.10	**0.59**	0.82	0.23	0.07	0.14	**0.68**
2004	0.71	0.21	0.10	0.10	**0.57**	0.84	0.24	0.07	0.09	**0.65**
2005	0.71	0.20	0.12	0.11	**0.60**	0.84	0.26	0.05	0.09	**0.67**
2006	0.71	0.17	0.11	0.13	**0.59**	0.84	0.29	0.05	0.10	**0.66**
2007	0.72	0.18	0.12	0.13	**0.58**	0.84	0.27	0.05	0.08	**0.62**
2008	0.72	0.22	0.12	0.10	**0.53**	0.84	0.30	0.06	0.08	**0.60**
2009	0.73	0.22	0.20	0.10	**0.57**	0.81	0.32	0.06	0.12	**0.64**
2010	0.75	0.20	0.12	0.09	**0.53**	0.81	0.27	0.04	0.11	**0.63**
2011	0.75	0.20	0.14	0.07	**0.51**	0.81	0.24	0.03	0.12	**0.58**
2012	0.76	0.23	0.14	0.10	**0.52**	0.79	0.22	0.03	0.10	**0.57**
2013	0.76	0.22	0.13	0.12	**0.52**	0.79	0.26	0.03	0.10	**0.57**
	China					**USA**				
year	NFSI (Rice)	NFSI (Wheat)	NFSI (Corn)	NFSI (Soybeans)	**NFSI (aggregate)**	NFSI (Rice)	NFSI (Wheat)	NFSI (Corn)	NFSI (Soybeans)	**NFSI (aggregate)**
2000	0.56	0.56	0.56	0.39	**0.55**	0.83	0.83	0.83	0.83	**0.83**
2001	0.56	0.56	0.56	0.39	**0.54**	0.83	0.83	0.83	0.83	**0.83**
2002	0.56	0.56	0.56	0.40	**0.54**	0.83	0.83	0.83	0.83	**0.83**
2003	0.57	0.57	0.54	0.30	**0.52**	0.83	0.83	0.79	0.83	**0.81**
2004	0.58	0.58	0.58	0.34	**0.55**	0.83	0.83	0.83	0.83	**0.83**
2005	0.57	0.57	0.57	0.27	**0.53**	0.83	0.83	0.83	0.83	**0.83**
2006	0.57	0.57	0.51	0.27	**0.52**	0.83	0.83	0.74	0.83	**0.78**
2007	0.57	0.57	0.57	0.24	**0.51**	0.83	0.83	0.83	0.83	**0.83**
2008	0.60	0.60	0.60	0.18	**0.51**	0.83	0.83	0.83	0.83	**0.83**
2009	0.61	0.61	0.61	0.22	**0.53**	0.83	0.83	0.83	0.83	**0.83**
2010	0.61	0.61	0.54	0.23	**0.51**	0.83	0.83	0.73	0.83	**0.77**
2011	0.62	0.62	0.57	0.27	**0.52**	0.83	0.83	0.77	0.83	**0.78**
2012	0.62	0.62	0.52	0.25	**0.50**	0.83	0.83	0.70	0.83	**0.74**
2013	0.62	0.62	0.51	0.23	**0.49**	0.83	0.83	0.67	0.83	**0.73**

<Appendix Figure 1> Commodity (Rice) NFSI of Korea: 2001-2013



<Appendix Figure 2> Commodity (Corn) NFSI of Korea: 2001-2013