To the Graduate Council:

I am submitting herewith a thesis written by Hiroyuki Takeshima entitled "Identification of the effective policy for the improvement of food security —The comparison of the impacts of domestic food production, economic growth and trade liberalization—" I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Daniel De La Torre Ugarte, Major Professor

We have read this thesis
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Accepted for the Council:

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IDENTIFICATION OF THE EFFECTIVE POLICY FOR THE IMPROVEMENT OF FOOD SECURITY

—The comparison of the impacts of domestic food production, economic growth and trade liberalization—

A Thesis

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ABSTRACT

Food insecurity and undernutrition are serious problems in many countries. The identification of the efficient way to improve the food security condition has become a primary political issue for each country.

Domestic food production growth, economic growth and trade liberalization have been listed as major solutions, with the increasing weight on the latter two. All of these three factors may improve each country's food security condition to some extent. However, the significance of the impact of each of these factors has not fully been compared. It is assumed one of these three factors has stronger impact on food security than the others have, and also the size and the significance of the impact may change under the different agricultural population ratio and the population size of the country. The identification of the most efficient factor is therefore helpful for policymakers to formulate the most effective policy to improve food security.

According to the analysis based on the historical trend, it is assumed that the domestic food production growth is generally more significant than economic growth and trade liberalization, and may be the only significant factor under the high agricultural population ratio. Countries with severer and more widespread undernutrition today generally have high agricultural population ratio. Therefore the result of this analysis suggests that the policies in countries with severe and widespread undernutrition today should be directed more toward the domestic food production growth, than toward economic growth and trade liberalization.

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ABBREVIATION

Abbreviation	Full title
DRCongo	Democratic Republic of Congo
EthiopiaPDR	People's Democratic Republic of Ethiopia
FAO	Food and Agricultural Organization
FAOSTAT	FAO Department of Statistics
GDP	Gross Domestic Product
IMF	International Monetary Fund
LDCs	Least Developing countries
LIED	Low-income food deficit countries
LnPGDP	Natural log of per capita GDP
North Korea	Democratic People's Republic of Korea
OPEC	Organization of Petroleum Exporting Countries
OPN	Market openness
Pcal	Per capita daily calorie intake level
PDFP	Per capita domestic food production
PTRB	Per capita trade balance with the equivalent of food imports extracted
SAPs	Structural Adjustment Programs
South Korea	Republic of Korea
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WAR	Political unrest

CHAPTER 1

INTRODUCTION

1. BACKGROUND

Food insecurity and undernutrition are serious problems in many countries. The international cooperative movements against the food insecurity and undernutrition problems have been reinforced especially through the last half century. However, the eradication of undernutrition has not yet been achieved in spite of these movements and unprecedented growths in the world food production.

The access to food as the basic human right first appeared officially as an internationally acknowledged concept in the Universal Declaration of Human Rights[1], proclaimed in 1948 by the United Nations General Assembly (United Nations, 1948). Since then, the existence of the food insecurities in certain regions of the world has been considered as one of the most fundamental obstacles against the successful achievement of the goal in the declaration.

In addition to the humanitarian perspective, economics has warned that the unsatisfactory nutritional status of significant portions of the population in certain countries today may result in severe future losses in human resources for those countries (Food and Agricultural Organization (FAO), 1996c). Undernutrition is also considered as one of the factors that have been decelerating economic growth in many developing countries, mainly because unsatisfactory nutritional status can generally lead to lower labor productivity (FAO, 1996c).

[1] It is set out in the Article 25 that "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food..."

As a result of the concerns about the consequences of food insecurity, the eradication of undernutrition has become a worldwide goal. In the 1974 World Food Conference, it was declared that the undernutrition among nearly eight hundred million people in the world would be eliminated within a decade[2]. In light of the failure to achieve this goal, the 1996 World Food Summit set a more realistic goal of halving the size of undernourished population, which is still approximately at eight hundred million, by 2015. However, "total reduction in global hunger achieved between 1996 and 2001 was only one-third of what would have been needed" (Rosset, 2002) to meet the goal by 2015. Consequently, the effective alleviation of food insecurity has remained one of the worldwide concerns.

In parallel with the above-mentioned movements, many studies have been conducted on the present situation and possible causes of food insecurities, with the aim of identifying the critical factors to improve food security. Among these factors, the domestic food production growth, economic growth and trade liberalization have been considered as the most important factors.

The domestic food production growth has conventionally been considered as the key factor to improve food security for each country.

The problem of food insecurity, however, has been more strongly linked with the failure in economic growth, especially with the problem of poverty (World Bank, 1986; Foster, 1992; Alexandratos, 1995; Maxwell, 1996). A study published by the World Bank

[2] In 1974, governments attending the World Food Conference had proclaimed that "every man, woman and child has the inalienable right to be free from hunger and malnutrition in order to develop their physical and mental faculties." The Conference had set as its goal the eradication of hunger, food insecurity and malnutrition within a decade (FAO, 1996a).

in 1986 associates the chronic food insecurity with problems of continuing or structural poverty and low incomes (World Bank, 1986). The Food and Agricultural Organization of the United Nations (FAO) stresses that poverty or the low income at both individual level and national level have been considered not only as the obstacles to the successful food production growth, but also as the factors that impede the access to food in both the domestic market for the individual people, and the international market for countries (FAO, 1996a). With this trend, the economic growth in developing countries has been gaining more attention as an important factor.

Another factor is trade liberalization. The promotion of trade liberalization with the aim of improving food security is supported in the 1996 Rome Declaration[3]. Because of the chronic excess food supply in several major food export countries, the trade liberalization and the consequential economic growth in food deficit countries have been emerging as the ideal solutions to improve food security in these countries (FAO, 2003). In the context of food security, the trade liberalizations for currently food deficit countries are generally aimed at the increases in per capita food imports, through the creation of the trade surplus (FAO, 1996d).

2. PROBLEM STATEMENT AND JUSTIFICATION

Pinstrup and Pandya-Lorch stress the importance of the role of the government on the food security improvement, mentioning that "the most depressing factor [to the very slow improvements in food security and nutrition in developing countries] is the apparent lack

[3] Rome Declaration, Commitment four, clearly mentions the importance of the market-oriented world trade system. Article 37 says "Trade is a key element in achieving world food security."

of political will by governments of developing countries to place the elimination of [...] food insecurity [...] at the top of the list of priorities" (Pinstrup, et al., 2001). Therefore policies implemented by the government are considered to have strong influences on the improvement in food security. In other words, the implementation of the aforementioned three policies by a government can have direct bearing on the food security in countries with food insecurity.

In many cases any combination of the domestic food production growth, economic growth and trade liberalization may be able to improve food security to a certain extent. In other words, a government is provided with several policy options to improve food security. The identification of the most effective combination of policies then has become a matter of concern for the government in each country.

Few studies have, however, compared the relative significance of the impacts of these three factors on food security. It has not been clearly analyzed how the relative significance of the impacts of these three factors differ based on each country's characteristics such as the agricultural population ratio or the population size. As a result, it has not clearly been answered which of these three policies should be prioritized in order to most effectively improve the food security in the country with widespread undernutrition.

The relationships between the individual factors and food security may be less clear if the relative significance of the impacts of these policies is not identified. For example, even though the strong linkage between poverty and food insecurity is mentioned by many studies (Foster, 1992; Alexandratos, 1995; Maxwell, 1996; FAO, 1996a), very few of them analyze why the significance of undernutrition, such as the undernourished

population ratio, differs largely between countries, or between the periods within one country, even if poverty and low income commonly exist among certain portions of the population in almost all the countries and throughout the whole period in each country.

The identification of the most significant factor to improve food security can help the government in a specific country or the international organization to allocate their available resources more efficiently to improve the food security in each country. This applies more to the case in which it is unclear for the government whether the promotion of one of these three factors can positively affect the other factors. In other words, it is not appropriate for a government to focus on only one of these policies to improve food security without comparing the significance of impact which any of these three factors has on the improvement of food security. For example, it can be less efficient utilization of its resources for a country to promote trade liberalization, if the promotion of the domestic food production is a significantly stronger force to improve its food security, and if there is no clear path through which the promotion of trade liberalization can significantly contribute to the domestic food production growth. As a result, it can be a serious political issue for each country which policy to prioritize among the domestic food production, economic growth and trade liberalization.

The FAO has stressed that trade liberalization can fully contribute to the food security improvement if it leads to the increase in the employment possibilities and earning opportunities (FAO, 1996d). For countries with high agricultural population ratios, the higher proportions of the employment source exist in the agricultural sectors and thus food production. The importance of the domestic food production growth is presumably higher in these countries than others, in the process of the food security improvement.

This may also apply to the country's population size. Countries with large population sizes and thus large scales of food demand may consider the size of the international food market smaller and less reliable (Ingco, Mitchell and McCalla, 1996). It can be assumed that the domestic food production is more important than the food imports for countries with large population size.

In order to identify the most effective way to improve food security among the domestic food production growth, economic growth and trade liberalization, a certain approach can be made to compare the significance of the impact that each of these three factors has on the improvement of food security. The results obtained from the comparison can be helpful for each country with specific character including its agricultural population ratio and population size, to improve its food security most effectively.

3. OBJECTIVES

The primary objective of this research is to identify and compare the significance of the effect of the domestic food production, economic growth and trade liberalization as possible factors to improve the food security in today's countries with low per capita calorie intake levels and widespread undernutrition. There are two specific objectives.

1. Compare the significance of the impact of the domestic food production, per capita gross domestic products (GDP), per capita trade balance, market openness and the existence of civil war on the average daily per capita calorie intake level in each country categorized by its agricultural population ratio and population size
2. Examine how the combination of above mentioned significance and the impact of each factor changes based on the country's agricultural population ratio and the population size

The per capita GDP is used to estimate the impact of economic growth, and the market openness and the per capita trade balance are used to estimate the impact of trade liberalization on the improvement of the average daily per capita calorie intake level. The existence of the civil conflict is taken into consideration to make the analysis more accurate.

CHAPTER 2

LITERATURE REVIEW

1. THE MESUREMENT OF FOOD SECURITY

The measurement of the level of food security has been the subject of much controversy, since it is generally difficult to describe the level of a complex concept like "food security" with a simple indicator.

The concept "food security" is defined in many ways. Maxwell et al. have found approximately two hundred definitions of food security in published writing (Maxwell, et al., 1992). According to the FAO definition, food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." The World Food Summit held in Rome in 1996 introduced three concepts; food availability, stability and access. These concepts are core characteristics of food security (FAO, 1996a). Food security for a country varies at the following different levels; global level, national level, the household level and at the individual level and the improvement of food security at one level is not necessarily the same as its improvement at the other levels (Thomson, et al., 1996; Foster, 1992; Ballenger, et al., 1992).

No complete measurement method, however, has been established that can thoroughly satisfy the aforementioned complex definitions. Consequently, it has been difficult to compare the level of food security either between the countries, or between the periods in a country.

Per capita GDP and per capita daily calorie intake level are widely used indicators to measure the level of food security. One study has recognized per capita GDP, especially the poverty level, as the representative indicator to measure the level of food security for both individual households and countries (Thomson, et al., 1996). Shane, et al. imply that the income level of two dollars per day or less is a clear indication of food insecurity (Shane, et al., 2000). The World Bank has located poverty as the root cause of chronic inadequate access to food for individuals and households (World bank, 1986). With this trend, increasing numbers of studies have started using the per capita income level as the indicator of food security.

The other representative indicator is the per capita daily calorie intake level. Let **Pcal** denote the per capita daily calorie intake level hereafter. Pcal is calculated as annual and national average and is used by the FAO[4] as one of the three indicators related to food security. The data are credible since they are generated by the FAO, and allow users to roughly compare the level of the food security between countries over four decades (South Centre, 1997).

Pcal is widely used as a representative indicator of food security although human nutrition is composed of several other components besides the calorie intake level. Even though the definition of food security has been "reflecting concerns about ... minor nutrient requirements" (FAO, 2003), Flores justifies the usage of the per capita calorie intake level instead of other nutrients such as protein, vitamin and fat, mentioning that the

[4] According to the South Centre, the FAO uses three indicators related to food security: calorie available per capita (cal/cap), the Aggregate Household Food Security Index (AHFSI) and the percentage of undernourished in the total population (UNNUR). However, the latter two are simply unavailable for most developing countries. (FAO, 1996c)

"calorie supply...is a fundamental indicator of the national food security" (Flores, 1997). Seckler and Amarasinghe state that "the single most important component of nutrition is calorie consumption per capita. ... With reasonably varied diets, if people satisfy their calorie requirements, they will also satisfy their requirements for protein, minerals and vitamins" (Seckler and Amarasinghe, 2000).

A study of the World Bank mentioned that "in countries in which many of the poor are subsistence farmers who neither sell nor buy food, food prices have no effect on food security" (World Bank, 1986). Kostov and Lingard, using the examples of countries in Eastern Europe, indicate that "the main feature of small-scale agricultural production is its loose, incomplete links with the market. ..... In many cases, the primary aim of production is self-sufficiency rather than for sale. Farm efficiency is not the main issue" (Kostov and Lingard, 2002). In this case food security is largely determined by their production level, and their income level has less relationship with their level of food security. This study suggests that per capita income level is not as significant as Pcal especially when describing the level of food security in a highly subsistence household whose members obtain a significant portion of the food from their own production rather than from the market.

Pcal, however, has several shortcomings. Possible problems of using Pcal as the indicator are pointed out by the South Centre (South Centre, 1997). For example, it is cautioned that the average daily per capita food availability data from which calories are calculated by the FAO may include "wide margins of error". It is also warned that, since Pcal is a national average, it does not give precise indications about regional or household

food security. Therefore Pcal cannot accurately describe the situation in which this insecurity exists at the household level, even if there is a food surplus at national level.

2. DOMESTIC FOOD PRODUCTION

Many studies have addressed the domestic agriculture as the main source of economic growth and rural employment in countries with high agricultural population ratios (Mellor and Adams, 1986; Hazell and Ramasamy, 1991; FAO, 1996c). The positive impact of the domestic agriculture on Pcal has often been shown from the perspective of its economic benefit for the majority of rural population. Mellor focused on the importance of the domestic agriculture as the source of the employment for rural poor populations in many developing countries, especially in which a significantly higher ratio of the population is employed in the agricultural sector. In addition to the promotion of employment, the FAO stresses that the growth of food supplies also reduces food prices and benefits food-purchasing households in rural and urban areas (FAO, 1996c). Hazell and Ramasamy, using the example of the green revolution, point out that the appropriate technological innovations in food production can reduce the production costs, create the employments among the poor farmers and thus improve the food security of the poor farmers.

Even if these studies deal with the agricultural industry instead of food production, the products mentioned in these articles are generally the staple food crops. Therefore, it can be said that the large part of the domestic food production growth is the source of economic growth and rural employment.

The direction to which the domestic food production affects Pcal is, however, unclear. Many studies state that the promotion of the export crops production and the food crops production have different effects on food security (Govereh and Jayne, 2003; Fleuret et al., 1991; Dione, 1989; Strasberg, 1997). According to these studies, the promotion of the export crops production can affect Pcal both positively and negatively. Pcal can be negatively affected when the export crops production is promoted so much that it significantly replaces the food crops production. A study conducted by Fleuret in Kenya reported that the substitution of the subsistent maize production to export-oriented coffee production in Tanta Hills in Kenya had led to the decline in the child nutritional status, although the coffee production helped the farmers generate higher cash incomes. Govereh and Jayne, on the other hand, point out that the promotion of the export-oriented crop production may stimulate private investments for the transportation infrastructure, fertilizers and other input materials in the region. As a result, fertilizers and input materials are made more accessible and profitable not only for the uses of export crops but also for domestic food crops, and private investment in transportation infrastructure to support cash crop activities has also raised the returns to smallholder grain production and grain traders' operations (Dione, 1989 and Strasberg, 1997).

As was already mentioned, food security for subsistence farmers is more directly affected by their food production level, and less affected by their income level (Kostov and Lingard, 2002; World Bank, 1986). The study of Cour shows that almost 50 percent of the crops produced are still directed to the home consumption in countries in the Sahel region in Africa (Cour, 2001). Food security can more primarily be affected by farmers' own food production where there are highly subsistence farmers.

Plateau mentions that the higher rural population ratio has a different impact on the regional food security from the impact under the higher urban population ratios (Plateau, 1995). Plateau suggested that the food distribution costs tend to rise in countries with a higher rural population ratio. This is because the total costs are higher to distribute food to each rural area located all over the country, rather than to distribute food to urban areas where large numbers of people live in geographically limited area. It may be indicated that the high rural population ratio and also probably the high agricultural population can be related with higher ratio of subsistence farmers[5]. In other words, the food shortage problem with the high ratio of subsistence farmers may be more strongly caused by the low production technology, rather than low food demand induced by low-incomes among consumers.

A weaker political influence of the agricultural sector on governmental policy has been a common phenomenon in the Third World, especially in African countries (Mellor, 1986; Platteau, 1995; Rooyen et al., 1998). In many African countries, it is common to tax the agricultural sector while excluding it from the representation in governance. As a result, policies in these countries become unfavorable for the development of agricultural production, and result in the insufficient "reinvestments in the agricultural and rural sectors through infrastructure, institution development and the human capital development" (Rooyen, et al, 1998). According to Lipton, a large part of the investments in most Least Developed Countries (LDCs) had been directed toward urban development, and shifted the resources away from agricultural production. This "urban bias" could be a

[5] Data from the FAO Department of Statistics (FAOSTAT) indicate that the rural population ratio and the agricultural population ratio in a country are generally close.

cause of the fundamental low-income and poverty widespread in significantly large portions of the agricultural population (Lipton, 1975). Research conducted by Eicher and Rukuni in Zimbabwe implies that the commercial farmer lobbies' strong influences on the government had led to the "Zimbabwe's first agricultural revolution in 1950-80", during which the Pcal in Zimbabwe had been improving steadily (Eicher, et al, 1994).

One studies examines the Structural Adjustment Programs (SAPs) introduced to many African countries through the 1980s and 1990s by the World Bank and the International Monetary Fund (IMF). Seshamani attributes the decreasing maize production in Zambia to market liberalization, mainly induced by the elimination of the maize subsidy in 1986, especially caused by the negative supply response of the small farmers who generally lack competent marketing skills to take advantage of market liberalization (Seshamani, 1999). Considering that the Pcal in Zambia continuously declined through the 1980s and 1990s, this negative impact on the domestic food production presumably led to the aggravation of the food security in Zambia.

Paarlberg indicates that a country's food security may rely highly on the domestic food production level, implying a weak relationship between the international grain market and food security in many developing countries (Paarlberg, 2000). In research conducted by Paarlberg, world grain market conditions are considered inappropriate indicators of the changing food security of developing countries. This is based on the fact that the demands for grains in many developing countries in 1974 and 1995-96 was not significantly low, even if these two periods were thought of as serious world food crises with tight grain stocks and high market prices (Paarlberg, 2000). The weak relationship between world grain markets and food security in many developing countries implied in

his research suggests that the food insecurity in some developing countries today cannot be fundamentally solved by the development of the world grain market.

3. ECONOMIC GROWTH

As was mentioned in Chapter 1, economic growth can improve food security by either increasing the domestic food production, or enhancing the demand for food. According to the FAO, "economic growth can enhance food security by increasing the individual's command over resources and thus their access to food" (FAO, 1996d). Therefore the role of economic growth on the improvement in food security can be that it contributes to both the domestic food production growth and the increase in food importability. A study of the United States Agency for International Development (USAID) concludes that the stunted economic growth in several African countries has been the "root cause[s] ... [of both] inadequate food production and low capacity to import foodstuffs" (USAID, 1994).

Some studies, however, argue that the impact of economic growth on food security improvement is not always positive. This is mostly because the policy of economic growth may result in the reduction in the public support for agricultural production. According to Mellor, the economic growth policy in the past was generally based on capital-intensive strategies and thus little effort was put into promoting the agricultural production growth (Mellor, 1988b). The FAO criticizes that macroeconomic policies adopted by many developing countries in the 1980s had often had negative impact on the public investment directed toward the agricultural sector (FAO, 1996d). The FAO also mentions that malnutrition can be highly reduced through national public action, even with the low national per capita income level (FAO, 1996c). Agcaoili-Sombilla and

Rosegrant indicate that 90 percent of the possible future drops in crop production in South Asian countries will be caused by the reduction in public research investment, while the impact of slow economic growth will account for only 10 percent (Agcaoili-Sombilla, et al., 1996). Poulton and Dorward, using the experience of Southern African countries, point out that market-based economic growth does not strengthen food security if markets are not functioning effectively, even though market-based economic growth is "a critical element in ... food security" (Poulton, et al., 2002). The study by Fleuret (1991) implies that the policy toward economic growth may aggravate food security if the policy has a negative impact on domestic food production growth.

4. TRADE LIBERALIZATION

With the comparative advantage, "the role of trade is that it allows domestic food consumption to be met more cheaply by less costly imported supplies" for a country (FAO, 1996d). The FAO also introduces the argument that "improved food security, as well as efficiency gains, may be achieved more satisfactorily, even in countries where agriculture remains a major contributor to GDP, by shifting resources into the production of non - food export crops and importing staple food requirements" (FAO, 2003). Mellor indicates that facilitating food imports from the food surplus countries can play a critical role to alleviate the food deficit in developing countries, even though domestic agricultural production is considered as a large source of rural employment (Mellor, 1986). Mellor also stressed that food imports are almost inevitable especially in those countries in the process of economic growth and high population growth and thus with rapidly increasing demands for food.

Increasing stability is considered as another benefit of trade liberalization. The price stability of the domestic food market is considered as a positive consequence of trade liberalization. Diaz-Bonilla and Thomas state that "food trade, along with stocks, helped reduce the variability of food consumption in developing countries to one-third to one-fifth of that of food production" (Diaz-Bonilla, et al., 2000). Dorosh mentions that the promotion of trade liberalization in Bangladesh and India through the 1990s had alleviated the food shortage problem in Bangladesh in 1997 and 1998 (Dorosh, 2001). Dorosh pointed out the fact that rice imports from India to Bangladesh had significantly made up the food deficit in Bangladesh, which was mainly caused by the flood-induced drop in the Bangladesh's rice production, and also led to the rice price stabilization in Bangladesh at the same time. According to Timmer, the food price stability contributes to the increased household investment in productive activities rather than in stockholdings (Timmer, 1989).

Several studies, however, argue that trade liberalization may also negatively affect food security, especially of low-income small farmers in less developed countries (FAO, 1996a; Ballenger, et al., 1992). The FAO implies that trade liberalization is generally associated with the decline in the domestic food price (FAO, 2003), and thus trade liberalization can have a negative overall effect on food security if many of the poorest households are dependent on agricultural production (FAO, 2003; Mellor, et al., 1986).

One study stresses the negative impact of trade liberalization on food security because of the rising food prices in the international market. Comparatively negative impacts caused by the Uruguay Round Agreement on the level of the food security in some African countries were predicted in the analysis of the World Food Model (WFM)

(Greenfield, 1996). In the analysis, it was predicted that the national per capita food consumption level in half of almost forty low-income food-deficit (LIED) countries in Africa would be exceptionally aggravated by the Uruguay Round Agreement. According to the analysis, generally food prices in the market will rise because of the decrease in the production in the currently subsidized food export countries and increases in imports in the high-income food import countries. These price rises will deprive the low-income food importing countries especially in Africa of purchasing powers, while benefiting most of the countries in Asia and Latin America. The levels of food security in Asia and Latin America are generally higher than the levels in most of the African countries. Therefore the liberalization of food trade may lead to the expanding disparity of the levels of food security between developing countries.

5. TRADE BALANCES

The surplus in the trade balance enables a country to import food and is one of the desired goals of trade liberalization. The FAO states that "holding foreign exchange reserves is the best guarantee that food consumption levels can be maintained...for countries relying on trade for food security" (FAO, 1996d). The United States Department of Agriculture (USDA) implies that a 1.3 to 2 percent increase in foreign exchange availability is associated with a 1 percent growth in food imports (USDA, 1999).

Some studies, however, argue with the positive impact of the trade balance on the food security improvement. Sarris indicated that a country with food deficit and constrained foreign-exchange can improve its food security by driving "toward self-

sufficiency, by reducing variability of grain requirements with help [...] of domestic buffer stocks and by improving the domestic crop information system" (Sarris, 1980). With the example of SAPs implemented in sub-Saharan African countries, Cheru pointed out that the policy to generate a foreign exchange reserve "often conflict[s] with long term development needs" and "the needs of small farmers ... and food security [is] ignored" (Cheru, 1992).

The credit for cereal imports provided by some financial institutions including the IMF may alleviate the damages of the sudden sharp decline in the trade balances or the import purchasing power of food importing countries (FAO, 1996d). Under this system, Pcal may be affected by the trade balances to a lesser extent.

6. POLITICAL DISORDER / SOCIAL UNREST

The significance of the political stability on food security is discussed in the field of the political science. Some studies address the existence of the internal war as the negative factor to affect Pcal. Bruck, using the studies conducted in Mozambique, points out that the peasant families were forced to reduce their labor supply on the farm and thus experienced the reduction in agricultural production during the period of the civil war (Bruck, 2001). Paarlberg (2000) also mentions the process in which civil conflict[6]

[6] The civil conflict can also affect food trade, especially in inland countries when a civil war or a conflict exists in neighboring countries which are located in between the inland countries and sea. This is because the political chaos and the consequential malfunction of transportation system may impede the inflow of foodstuffs to the inland country.

However, since it is difficult to obtain the data about the each route through which foodstuff is transported, the civil war in neighboring countries is not taken into consideration in the following analysis.

generally deprives the farmers of their ability to produce agricultural products followed by comparatively high probability of food insecurity, implying that a healthy growth in the domestic food production is a critical factor for the food deficit countries to improve their food security. Marchione addresses the linkage between the civil conflict and food insecurity by mentioning that the civil conflict can not only damage the domestic food production, but also make it difficult for a government to provide the "right to food by means of market systems" (Marchione, 1996).

7. THE POPULATION SIZE

The population size of a country may affect the policy of food security improvement by the government. Ingco, et al. implies that countries with large population often pursue policies of food self-sufficiency (Ingco, Mitchell and McCalla, 1996). According to Ingco et al., it is because the relative size of the amount of food available in the international market becomes smaller for the countries with larger population size, and thus the international food market is considered as less reliable source for largely populated countries than for countries with relatively small population sizes.

CHAPTER 3

CONCEPTUAL FRAMEWORK

The contribution of this research is to measure the relative significance of the impacts of the domestic food production, economic growth and trade liberalization on food security, and how this relationship of each impact varies based on the country's agricultural population ratio and the population size.

As was mentioned in Chapter 1, the country's food security can be described as the following formulation:

Food security = f (domestic food production growth, economic growth, the degree of trade liberalization)

1. THE LEVEL OF FOOD SECURITY

1-1. The measurement of food security – income level or the per capita calorie intake level

In this research, per capita daily calorie intake level (Pcal) is used as the indicator of food security in each country. In addition to the justification of the usage of Pcal supported by Flores (1997), Seckler et al. (2000), and Kostov et al. (2002), the usage of Pcal can be justified against the problem suggested by the South Centre.

1. Even if the estimated Pcal can include a certain degree of errors, the estimated per capita income level cannot be free from the same degree of errors. Thus using the per capita income level as the alternative indicator does not solve the problem of the errors.
2. Although Pcal may not be able to explain the difference in the food security between internal regions and between households or individuals, there is no clear evidence that those minor differences are always large enough to render Pcal as totally unreliable. For example when Pcal increases, there is no clear evidence

that the actual value of the change in Pcal is less significant than the possibility that the minor difference suddenly expands and the significant number of population experience the decrease in Pcal.

In this research, Pcal is assumed to be more appropriate than the other representative indicator, the per capita GDP. One reason is that the per capita GDP is not necessarily related with Pcal especially in countries with the lower Pcal and severe undernutrition, as is shown in later sections. Another reason is that the per capita GDP level is appropriate as the potential ability to obtain a certain amount of calories but is not as accurate as the per capita daily calorie intake level to describe food security.

As was shown in Chapter 2, the usage of Pcal is also recommended by Flores (1997), Seckler and Amarasinghe (2000), even if the nutritional condition can also be determined by the amount of many other components including protein and vitamins.

Therefore, in this research, Pcal is used as the indicator to describe the food security.

1-2. Per capita calorie intake level and the food security

As was mentioned in the former Chapter, food security has different characteristics at the different levels, from global, national, household and individual (Thomson, et al., 1996; Foster, 1992; Ballenger, et al., 1992; FAO, 1996d 3.2). The calculation of Pcal is based on both food availability and the amount consumed as food. Pcal may be associated with the national food security considering that the data are aggregate at the national level. However, the amount consumed as food may both be determined by the food availability and by the income distribution. In other words, Pcal may not only reflect the national food security but also the household and individual food security to some

extent. Therefore, food security dealt with in this research is the mixture of the national food security, the household food security and the individual food security.

2. PER CAPITA DOMESTIC FOOD PRODUCTION

2-1. Per capita domestic food production (PDFP) and Pcal

Let PDFP denote the per capita domestic food production level. The growth in PDFP can contribute to the improvement of Pcal in two ways. One way is through the economic benefit and the other is through the increase in the food availability.

Based on studies by Mellor, Adams (1986), Hazell and Ramasamy (1991), the growth in the domestic food production generally raise Pcal. It raises Pcal for the rural poor farmers through the income growth and the creation of the employments, while it raises Pcal for the urban poor consumers through the decreases in food prices.

With the suggestion made by Kostov and Lingard (2002), Pcal of the farmers' household can be highly improved by their own food production growth if significantly large portions of their food consumptions are provided from their own food production.

2-2. Measurement of the per capita domestic food production

The measurement of PDFP is defined in order to identify the significance of the impact which the level of PDFP has on Pcal. In this research, PDFP is measured as follows:

> Per capita domestic food production (PDFP): Per capita calorie intake level (cal/day) provided by domestically produced food crops

PDFP is calculated using Pcal, the ratio between the domestic production, net import, total supply and food supply for each commodity. Food supply is described as:

Food supply (F_{it}) = $Dp_{it} + M_{it} + S_{it} - X_{it} - NF_{it}$

i = Commodity (Commodities are based on FAO food balance sheet; i = wheat, rice, …, aquatic plants)[7]
t = year (t = 1961, 1962, …, 2001)
F_{it} = Food supply of a commodity (tones, FAOSTAT)
DP_{it} = domestic production of a commodity (tones, FAOSTAT)[8]
M_{it} = the amount of a commodity imported (tones, FAOSTAT)
X_{it} = the amount of a commodity exported (tones, FAOSTAT)
S_{it} = the net amount of a commodity provided from stock (tones, FAOSTAT)
NF_{it} = the amount of a commodity used for other utilities than food, such as animal feeding, seed or industrial use (tones, FAOSTAT)
$F_{it} + NF_{it}$ = total use of a commodity

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[7] Complete list of commodities included is in Appendix A, "Commodity list". Food balance sheets provided by the FAO include such commodities as sugar, oil products, vegetables, fruits, spices, stimulants and alcoholic beverages. These products may generally be evaluated by their unique roles or components rather than by calories they contain. Thus it may not be realistic to evaluate all products only by the calories they contain. For example, in terms of calorie production, the ability to produce 1000cal/person/day of wheat and the ability to produce 1000cal/person/day of cocoa beans have totally different effect on country's food security condition, since no country consumes 1000cal/person/day of cocoa beans.

However, in this research commodities mentioned above are also considered as the important source of calorie production. This assumption is based on several facts. First, one of the differences in calorie consumption structure between 1961-65 and 1997-2001 is generally increasing per capita calorie intake from oil products mainly represented by soybean oil and palm oil, and sugar. Second, generally the proportion of calorie intake supplied by these commodities has been significantly small and has shown little change through 1961-2001, so that including calorie intake from these commodities does not affect the description of trend in total per capita calorie intake level. Third, it has been observed that consumption of fruit products in some African countries has been significantly large. For instance, per capita calorie intake from plantains in DRCongo have accounted for generally ten to twenty per cent and the decline in the per capita calorie intake level from plantains has accounted for 30 percent of total decline in per capita calorie intake in DRCongo. From these viewpoints, eliminating these commodities from total calorie consumption does not seem to be appropriate.

[8] Dp denotes the amount of the agricultural and fishery products which can be consumed as food. Therefore, Dp does not include the production of certain commodities such as the tobacco and the cotton (from which cottonseed oil had been extracted). This applies also to M, S, X and NF.

PDFP is then calculated as:

(*) $PDFP_t = \sum_i Pcal_{it} * DP_{it} / (F_{it} + NF_{it})$[9]

$Pcal_t$ = Per capita calorie intake in year t (cal/day, FAOSTAT)
$PDFP_t$ = Per capita calorie supply from domestic food production in year t

Equation (*) describes how great a portion of calorie intake from certain product is provided by domestic production of that product[10]. Equation (*) describes how large the domestic per capita calorie production level is compared to Pcal. Even if the food production is described as the aggregate weight of whole food composed of several kinds of crops or livestock in many other studies, PDFP in this research is described as sum of calories which each crop or each livestock product individually provides[11]. It must be noticed that PDFP is always positive and can exceed Pcal for both individual product and

[9] Exceptions are applied to the calculation of PDFP for some products. See Appendix B, "PDFP calculation".

[10] It must be recognized that PDFP is not equal to total calories produced domestically, because some part of calorie supply from domestic production can be applied to animal feed, seed for next term's production and other industrial resources.

[11] PDFP is described as the sum of calories from each product rather than the weight of each product. This is because different kinds of crop or livestock contain different level of calories. For example, data from FAOSTAT suggest that one kilogram of rice after milled generally contains 20 - 30 percent more calories than one kilogram of wheat. Generally one kilogram of wheat contains two to four times more calories than main root crops such as cassava, potatoes and yams. Since food in total is described as the conglomerate of products with different calorie containment level, sum of calorie containment level is used rather than sum of weight.

Suppose country A consumes the agricultural products as shown table below.

Product	Cal / person, day	Domestic Production	Net import + Stock	Total supply	Consump-tion as food	PDFP for each commodity
Wheat	1,000	300,000t	900,000t	1,200,000t	1,000,000t	250
Maize	800	1,100,000t	400,000t	1,500,000t	700,000t	587
Cassava	700	1,650,000t	-100,000t	1,550,000t	1,500,000t	745

In this case, Pcal = 2,500cal (/person, day), PDFP = 1,000*300,000/1,2000,000 + 800*1,100,000/1,500,000 + 700*1,650,000/1,550,000 = 250 + 587 + 745 = 1,582cal.

in total, when a significantly large amount of domestically produced calories is exported and imported calories do not exceed the export.

It must be noticed that the calculation of PDFP here is based on how many per cent of total supply of a certain product is consumed as food. For example, if 70 percent of the total supply of maize is consumed as food, the PDFP for maize is calculated as 70 percent of the per capita domestic maize production. The calculation of PDFP here is based on the assumption that 70 percent of the maize production was originally aimed at food consumption, and the remaining 30 percent of the maize production was originally aimed at non-food consumption[12]. This may not be realistic since the ratio of food consumption and non-food consumption can be determined more by demand side factors rather than by supply side factors. However, this research assumes that PDFP is measured more accurately if this ratio is taken into consideration. For example, the 30 percent of the non-food consumption of maize may be the important source of the economic activity and the income, including the livestock industry or the non-agricultural industry, and cannot simply be counted as the food.

The definition of PDFP also interprets that this concept is calculated based on the amount of food which is consumed in individual country. In other words, domestic

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[12] For instance, if 70 percent of the total demand of commodity A is as food consumption and 30 percent is as non-food consumption, it is assumed that 70 percent of the domestic production and 70 percent of the import are directed to food supply and 30 percent of each is directed to non-food supply.

It must be noticed that because of this presumption, this analysis may slightly lack actuality. For example, it can be possible in certain countries that imported cereal crops are used only for the feed for animals and cereal crops produced domestically are not. In this case, even though the calories from these cereal crops are perfectly supplied by the domestic production, it will not be calculated to be 100 percent because net import of this product accounts for a certain portion of total supply.

productions of some agricultural products which had not been consumed as food in certain period of years are not included in PDFP[13].

2-3. The implication of concept

The methodology introduces a somewhat different viewpoint from the prevailing viewpoint when dealing with the food insecurity problem.

Attention is paid to the proportion that the calorie intake from each commodity accounts for in the total calorie intake level, and so does the importance of commodity on each country's Pcal. For example, if wheat shares the largest proportion of the calorie intake source for a certain country, most of the attention is paid to wheat in that country. In other words, if the calorie intake level from wheat is not significantly large in some country, too much attention should not be paid to the change in wheat production, even if wheat is one of the largest calorie intake sources in the world and the trend of wheat production, trade, or price change is generally of serious concern in many studies dealing with food security. This principle is also applied to the products such as maize since a relatively large proportion of maize is consumed as a non-food, such as feed or other industrial use, in a large number of countries.

Products such as the cotton or the tobacco have relatively smaller importance in this research. Even though the small portion of the cotton is considered as a calorie intake

[13] For example, sunflower seeds in China had not been consumed as food until 1977 even though they had been produced domestically mainly to produce the sunflower seed oil. Thus, according to the definition, PDFP does not include the domestic production of sunflower seeds during the period of 1961 ~ 1977, although this does not mean that sunflower seeds had not been produced domestically during this period (PDFP includes the calorie intake of the sunflower seed oil during this period).

source basically as cottonseed oil, the trend in the cotton production is not highly focused on by this methodology as long as it does not account for the large portion of the calorie intake.

3. ECONOMIC GROWTH

3-1. Economic growth and food security

Economic growth can contribute to the improvement in Pcal both from the supply side and the demand side.

The low Pcal is the result of either the shortage in the food production or the lack of the sufficient purchasing power on the demand side, or by both of these.

The economic growth and the income growth of farmers can contribute to the increase in the food production level, by allowing farmers to introduce and apply new technologies with higher costs but with higher productivities. This impact may be bigger if a larger part of the lowness in Pcal is caused by the low food production level. The income growth of the farmers is also the factor to raise the food demands by farmers, and thus the income growth stimulates the domestic food production growth.

The economic growth and the income growth of the urban consumers can contribute to the improvement in Pcal by stimulating food demands. The income growth for the consumers allows them to purchase more food from either the domestic market or the international market, and thus increases their Pcal. This impact is bigger if a large part of the population is the urban dwellers and non-farmers.

As is mentioned by the FAO, Agcaoili-Sombilla, Rosegrant and Fleuret, economic growth can also negatively affect Pcal if the macroeconomic policy leads to the significant reduction in the public investment toward the agricultural production growth.

3-2. The measurement of economic growth

The per capita GDP is defined by the United Nations, Department of Economic and Social Affairs[14], as the standard measure of economic growth.

Let **LnPGDP** denote the natural log of per capita GDP. LnPGDP is used as the independent variable in the regression model instead of per capita GDP. The natural log of per capita income level is used in study conducted by the World Bank to identify a "poverty line" and a "famine line" (World Bank, 1986). Here it is assumed that per capita GDP tends to change exponentially while Pcal changes linearly. In other words, per capita GDP can change exponentially while food production and food demand generally change linearly. Twice higher per capita GDP generally may generally result in less than twice more food production or food demand. Therefore LnPGDP is considered to be more appropriate as the independent variable.

[14] United Nations, Department of Economic and Social Affairs: Division of Sustainable Development.

4. TRADE LIBERALIZATION

4-1. Trade liberalization and food security

Trade liberalization can contribute to the improvement of Pcal. According to the free trade theory, the Pcal in countries with food insecurity can be improved by the promotion of trade liberalization.

The promotion of international trade leads a country to focus their resources into the specific industry or the production of the specific commodities on which the country has the comparative advantage (FAO, 1996d). Countries with food shortage can grow their economy and increase their income levels by switching their resource allocation from the domestic food production into the production of other commodities or into other industries on which they have comparative advantages. Consequently, it is assumed that the increase in food imports in these countries more than compensate the decline in their domestic food production level and improve their Pcal.

4-2. The measurement of trade liberalization

The openness ratio (denoted as **OPN** hereafter) is suggested as a rough indicator of the degree to which a country is integrated into the international market (Hufbauer, et al, 1998). OPN is the country's share of imports and exports combined relative to its GDP. The indicator can be greater than one. OPN is used to examine how Pcal is affected by the openness of a country's market to the international market.

In addition to OPN, this research includes per capita trade balance with food import extracted, denoted as **PTRB** hereafter, as another indicator of trade liberalization. The inclusion of PTRB is aimed at examining whether the surplus in the trade balance is

necessary to improve Pcal, or the deficit in the trade balance has a negative impact on Pcal. It must be noticed that PTRB is based on the trade balance before the equivalent value of food import is extracted, and is not based on the simple difference between total merchandise export (1995US$) and total merchandise import (1995US$). Therefore PTRB measures the ability of an individual in a country to import food[15]. The increasing surplus in PTRB is generally considered as a primary benefit of trade liberalization for many food deficit countries, even if the large surplus in PTRB is not always the necessary consequence of trade liberalization.

The possible benefit of trade liberalization for developing countries may not only be the increase in the ability to import food. However, PTRB as the ability to import food, is still used as an indicator of trade liberalization in this research. According to the FAO, "the amount of foreign exchange available to pay for necessary food imports, is a key determinant of the national food security" (FAO, 1996d 3.2). PTRB is presumably a representative and influential indicator of "the amount of foreign exchange available to pay for necessary food imports", even if they are not identical. In many countries with food insecurity, the level of domestic food production is not high enough so that the surplus is exported to the international market. If the liberalization of food trade is used to improve Pcal for these countries, their policy may generally be directed to obtain the foreign exchange and create a surplus in the trade balance to make a room for food import. Thus examining the impact of PTRB on Pcal is appropriate to examine the impact of trade liberalization on the improvement of Pcal.

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[15] However, PTRB is not the only description for the ability of a country to import food. It is possible for a country to import foodstuffs if it has enough GDP level, even if PTRB is not largely positive enough.

PTRB is used in addition to OPN because the positive PTRB may be the common desired goal under the promotion of the trade liberalization for countries with food shortage. On the other hand, OPN is a more general indicator of trade liberalization and this is used because the consequence of trade liberalization is not only the increase in PTRB and thus OPN may affect Pcal through other paths than PTRB. For example, OPN may lower the price of imported fertilizers or machinery and thus contribute to the increase in the domestic food production. In this situation, Pcal may improve without significant changes in PTRB. Therefore, OPN is used separately with PTRB.

5. THE AGRICULTURAL POPULATION RATIO AND THE POPULATION SIZE

Under a high agricultural population ratio, as was mentioned before, the domestic food production growth tends to have more impact on the improvement of Pcal than economic growth and trade liberalization have. On the other hand, economic growth and trade liberalization tend to have a stronger impact on Pcal under a lower agricultural population ratio.

The population size of a country may influence how strongly PDFP affects Pcal, or how the government's food policy is directed toward more to the domestic food production or more to food import. As was mentioned in Chapter 2, Pcal in countries with large population sizes may be determined by PDFP more strongly. This is because countries with large population sizes tend to pursue the food self-sufficiency and thus tend to grow the domestic food production in order to improve their food security. This is also because it may be more difficult for a country with a large population size, to make

up the food deficit by food imports, than for a country with a smaller population size. This implies that Pcal in countries with larger population sizes are more strongly affected by PDFP.

It is estimated that population growth in developing countries will be higher than developed countries through 2010 (Alexandratos, 1995). This roughly indicates that population sizes relative to the size of the international food market in countries with food insecurity today are expected to be larger in the future compared with the population sizes in countries with less food insecurity, unless it grows as fast as the population sizes in these countries with food insecurity. With this estimation and the above mentioned hypothesis, it can be assumed that the impact of the domestic food production level on Pcal in those countries becomes larger and stronger in the future.

CHAPTER 4

METHODS AND PROCEDURES

1. MODEL SPECIFICATION

1-1. Variables

Five independent variables are used to explain the dependent variable, Pcal. The following is the definitions and measurement of the variables being used. As was mentioned in Chapter 3, PDFP represents the domestic food production level, LnPGDP represents economic growth, OPN and PTRB represent trade liberalization, and WAR represents political unrest.

i = country
j = group
t = year
Dependent variable:
Pcal$_{ijt}$: Per capita calorie intake level (cal/day, average in each year)
(i = country; j = 1, …, 9, OPEC; t = 1961, …, 2001)

Independent variables:
PDFP$_{ijt}$: PDFP of country i in group j, in year t.
LnPGDP$_{ijt}$: Natural log of per capita GDP (Constant 1995 US$)[16]
OPN$_{ijt}$: The openness of the domestic market to the international market (= (Total merchandise export + Total merchandise import) (Constant 1995 US$) / GDP)
PTRB$_{ijt}$: Per Capita Trade balance available for food purchase from abroad (= [Total merchandise export – (Total merchandise import – Food import)] [17] / population, Constant 1995 US$)
WAR$_{ijt}$: Dummy variable for the year of civil war (Yes = 1, No = 0)[18]

Individual variables include a dummy variable for the existence of the civil war, since the impact of civil war on Pcal may be significantly large so that Pcal can be affected by

[16] World Development Indicator, World Bank.

[17] FAOSTAT. Data for total merchandise export, total merchandise import and food import were all described by contemporary US$. Thus, they were calculated converting the value of US$ in each year into the value of US$ in 1995.

[18] Peace Pledge Union Online website (http://www.ppu.org.uk/war/countries).

the existence of civil war outside of the other independent variables. Therefore the inclusion of this variable can make the result more accurate.

1-2. Functional form

The original model is basically formulated as:

$$Pcal_t = \alpha + \beta_0 * PDFP_t + \beta_1 * LnPGDP_t + \beta_2 * OPN_t + \beta_3 * PTRB_t + \beta_4 * WAR_t + u_t$$

It is assumed, by using this model, that the dependent variable is linearly related with each independent variable individually. This assumption is held even though this may not be the most accurate model, since the model has not been clearly specified and developed in the past studies to compare the significance of the impact that each independent variable has on Pcal. The objective of this research can be achieved by the comparison of the sign and the significance of each estimator β.

The model assumes that Pcal in year *t* is explained by the independent variables of the same year. The other factors, including the stock changes may have lagged impacts on Pcal; thus this assumption may not be fully realistic. However, the span of the lag is difficult to identify and describe in the model. Therefore, the presented form is used.

2. DATA

2-1. Sample of countries

Countries in this research are selected by the following standards:

1. A Country with the population size of more than 1 million in 2001.
2. A Country whose Pcal was or is below 2,400 cal/day in at least one year between 1961 and 2001[19].

[19] Due to the unavailability of data, Somalia, Iraq and Afghanistan are not included.

The cutoff point of the population size is set to select the countries whose food security change can significantly affect the size of the undernourished population in the world. Besides, since the unit used in this analysis is the country and not the population, the inclusion of countries with significantly small population may skew the results of the analysis. Therefore it is appropriate to set a cutoff point to the population size.

The cutoff point of 2,400 cal/day is used to identify countries which have had experienced undernutrition with a certain level of prevalence. Based on the regression analysis conducted by the author, it is estimated that Pcal and the ratio of undernourished population in a country have a strong relationship (see APPENDIX C. Pcal and the undernourished population ratio). According to the Equation 1 shown in Appendix C, a country is expected to have approximately 20 percent of its population undernourished with Pcal of 2,400 cal/day. Since this research exclusively focuses on the countries with food insecurity conditions, the countries without significant prevalence of undernutrition are not included. This is based on the assumption that Pcal in well-fed countries may be affected more by the other factors like people's preference or the health concerns, rather than those factors used in this research such as the domestic food production or the per capita GDP.

With these two selection standards, this research covers approximately the population of 4.7 billion which is 97 percent of the population in all developing countries in 2001 (FAOSTAT, 2001).

2-2. Grouping of countries

Ninety-nine countries are classified into nine groups based on each country's average population size and average agricultural population ratio (%) during 1961 to 2001. Three reasons explain this classification.

(1) Both the population size and the average agricultural population ratio (%) tend to change steadily without significant irregularities. Therefore they may not be appropriate for being used as the independent variables in the regression, even though these two factors are thought to have significant impacts on the government's food security policy.
(2) A country's population size may have significant impact on a government's decision about the desired level of the dependence of its food security on the international market.
(3) The agricultural population ratio (%) may have a significant impact on the government's decision about the relative importance of the agricultural policy to the others. For example, a larger agricultural population ratio may lead to strong political power in rural areas and the domestic agricultural industry, and thus let the government put more weight on the domestic food production.

All the groups are listed in **Table 1**.

Even though the estimated impact of the population size is described in (2), there is no clear and reasonable level of the population size which can be used as the border line. Therefore, here the method is that all countries are put in order based on the average population size, and categorized into three groups so that the most-populated group contains one-third of the countries from the top, and the medium group contains the next one-third countries, while the remaining countries belong to the least-populated group.

Each of three groups is then divided into another three groups based on the average agricultural population ratio in each country. The borders here are set at 50 percent and 75 percent.

Table 1. Groups in regression

Higher agricultural population ratio* (≥ 75%) ↔ Lower agricultural population ratio* (< 50%)

More population*

↑ 11,482,000

10,968,000 ↓

4,504,000 ↑

4,366,000 ↓

Less population*

Group 1		Group 2		Group 3	
Nepal	94	China	74	Peru	41
Ethiopia (PDR)	90	Viet Nam	74	Algeria***	40
Uganda	86	Sudan	73	Iran***	39
Tanzania	85	Bangladesh	72	Mexico	39
Kenya	82	DRCongo	71	Colombia	37
Mozambique	80	Thailand	64	Brazil	35
(Myanmar)**	76	India	63	South Korea	31
		Pakistan	62	Uzbekistan	30
		Ghana	60	Chile	22
		Indonesia***	56	Venezuela***	20
		Egypt	55	(North Korea)**	45
		Morocco	55	(Iraq)**	32
		Nigeria***	54		
		Sri Lanka	52		
		Philippines	51		
		(Afghanistan)**	73		
Group 4		**Group 5**		**Group 6**	
Rwanda	93	Zimbabwe	72	Ecuador***	43
Burundi	93	Haiti	71	Syria	42
Burkina Faso	92	Cameroon	70	Saudi Arabia***	40
Niger	91	Yemen	69	Tunisia	39
Guinea	90	Cote d'Ivoire	66	Dominican Republic	37
Mali	88	Guatemala	59	Tajikistan	36
Chad	87	Bolivia	50	Azerbaijan	28
Malawi	84			Kyrgyzstan	28
Madagascar	81			Georgia	22
Senegal	80			Croatia	11
Angola	76			(Cuba)**	27
Zambia	76				
Cambodia	76				
(Somalia)**	78				
Group 7		**Group 8**		**Group 9**	
Guinea-Bissau	87	Sierra Leone	71	El Salvador	49
Papua New Guinea	84	Mauritania	70	Lesotho	41
Gambia	84	Benin	70	Nicaragua	40
Central Africa	84	Togo	69	Mongolia	40
Laos	79	Botswana	64	Panama	36
Eritrea	78	Gabon***	63	Costa Rica	35
Liberia	76	Namibia	63	Turkmenistan	35
		Albania	59	Jamaica	30
		Honduras	57	Libya	25
		Republic of Congo	56	Jordan	23
		Paraguay	50	Macedonia	16
				Lebanon	15
				Armenia	14
				Trinidad and Tobago	14
				(Bosnia Herzegovina)**	7
				Kuwait	2

*Average through 1961 to 2001. **Due to the unavailability of data, entire period of these countries is excluded from the regression. ***OPEC countries.

Source: FAOSTAT

The level of 50 percent can be explained as the border line by which all countries are divided into groups based on whether the agricultural population has been the majority of the whole population in the country and thus the agricultural population has had significant influence on the government policy through 1961 to 2001. The level of 75 percent is set as another border with the assumption that the proportion of subsistence farmers may be significantly high in those countries with the agricultural population ratio of more than 75 percent, and vice versa. It is clear that, the result obtained from the following analysis has a certain level of limitation, and may change depending on the way of the grouping, because of this assumption on which the way of the grouping of the countries is based.

Countries which belong to the Organization of Petroleum Exporting Countries (OPEC) are categorized as tenth group[20]. The OPEC countries had generally experienced the large increase in their PTRB in the mid-1970s to the beginning of 1980s. Therefore the identification of the significant factors on Pcal in the OPEC countries can typically describe how PTRB affects food security, and whether PDFP is still a significant contributor to improve Pcal under the highly positive PTRB level.

Pcal and data used to calculate PDFP, PTRB and OPN are based on the data of the FAOSTAT. The data of per capita GDP (1995US$) are obtained from the World Development Indicators of the World Bank.

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[20] Ecuador and Gabon had been the OPEC members in 1973 ~ 1992 and 1975 ~ 1994, respectively. However, data of Ecuador and Gabon in 1961 ~ 2001 are included in the analysis.

3. MODEL SPECIFICATION

3-1. Panel data analysis

The analysis of the effect of the aforementioned five independent variables on the change in Pcal requires both time-series analyses on one country and cross-section analyses between countries. These data are termed as *pooled time series, cross-section data*, or more simply as *panel data* (Ramanathan, 2002). Therefore, a panel data analysis is used in this research.

The estimated equation is originally as follows:

$$Pcal_{ijt} = \alpha_j + \beta_{j0}*PDFP_{ijt} + \beta_{j1}*LnPGDP_{ijt} + \beta_{j2}*OPN_{ijt} + \beta_{j3}*PTRB_{ijt} + \beta_{j4}*WAR_{ijt} + u_{ijt}$$

$$u_{ijt} = \mu_{ij} + v_{ijt} \qquad \text{-------- (1)}$$

(i = country, j = group, t = year)

The error component u_{ijt} is composed of μ_{ij} and v_{ijt}. μ_{ij} "denotes the unobservable individual specific effect and v_{ij} denotes the remainder disturbance" (Baltagi, 2001). μ_{ij} is the error component based on the cross-sectional part, and v_{ijt} is the error component based on the time-series part.

μ_{ij} plays the role as the constant term which is specific to the country i. μ_{ij} is used to take into account the effect of more indigenous characters of the country, such as the land fertility level and the potential production ability. Since it is thought to represent the indigenous characters of the country, μ_{ij} is constant and assumed not to vary depending on the time t.

3-2. Autocorrelation

Since the model includes the time-series analysis, the presence of the autocorrelation problem is highly predicted from the original model (1).

Durbin-Watson statistics suggests that there is a strong indication of autocorrelation problem in all groups based on the first regression with the formula (1). Baltagi (2001) assumes that under the presence of the autocorrelation, the v_{ijt} is serially correlated while the μ_{ij} follows $\mu_{ij} \sim IID\ (0, \sigma_\mu^2)$.

With this assumption, Baltagi suggests that the autocorrelation problem can be solved by including the autoregressive (AR) term in the model. The original form of the model with the fixed effects is described as:

$$y_{it} = \alpha_i + x_{it}'\beta + u_{it}$$

$$u_{it} = \mu_t + v_{it}$$

This model can be transformed into

$$y_{it} = \alpha_i + x_{it}'\beta + u_{it}$$

$$u_{it} = \mu_t + v_{it}$$

$$v_{it} = \rho\, v_{it-1} + \varepsilon_{it}$$

where ρ is the first order serial correlation coefficient. It can be noticed that ρ is set to be common and is not specific to i.

3-3. Model estimation

The model is estimated using the Eviews 4.1, the econometric software produced by the Quantitative Micro Software, LLC. The method of the panel data estimation is described in Eviews 4 user's guide, p.553 ~ p.558 "Technical Discussion".

With Eviews 4.1, the unique method is used to estimate the model including the autoregressive (AR) term. See Appendix D, "the estimation of the model with AR(1) term".

After the inclusion of AR(1) term, the model is transformed into the new model:

$$Pcal_{ijt} = \rho_j * Pcal_{ijt-1} + (PDFP_{ijt} - \rho_j * PDFP_{ijt-1}) * \beta_{j0} + (LnPGDP_{ijt} - \rho_j * LnPGDP_{ijt-1}) * \beta_{j1} + (OPN_{ijt} - \rho_j * OPN_{ijt-1}) * \beta_{j2} + (PTRB_{ijt} - \rho_j * PTRB_{ijt-1}) * \beta_{j3} + (WAR_{ijt} - \rho_j * WAR_{ijt-1}) * \beta_{j4} + \varepsilon_{ijt}$$

where ρ_j is the first order serial correlation coefficient for the group j.

CHAPTER 5

INTERPRETATION OF THE RESULT

1. SUMMARY OF THE RESULT

The summary of the regression result is shown in Table 2. The constant term for each country is not included in the table since it is not related with the objective of this research. Table 3 shows the calculated elasticity of each variable for each group.

Highly significant estimators for AR(1) term imply that the error terms are serially correlated. This suggests that the specified model may not be accurate enough. Therefore the result is interpreted with the consideration of this fact.

From Table 2, the following facts are indicated about the effect of each independent variable on Pcal.

(1) PDFP has significantly positive effect on Pcal in all groups. PDFP seems to have larger and more significant effect on the Pcal in the groups with higher agricultural population ratios, especially in the groups with larger population sizes.

(2) LnPGDP has generally positive effect on Pcal. However, LnPGDP does not seem to have significant effect on the Pcal in group with higher agricultural population ratio and larger population size such as Group 1, 4 and 5[21].

[21] In Group 4, it is significant at the .10 level, however not significant at the .05 level.

Table 2. Regression results*

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	OPEC
PDFP (cal/day)	0.31	0.09	0.08	0.09	0.05	0.04	0.22	0.11	0.14	0.14
	(10.54)	(7.36)	(3.22)	(7.10)	(3.46)	(2.88)	(4.79)	(3.91)	(5.73)	(5.36)
LnPGDP (1995US$)	88.40	325.81	196.37	109.71	95.48	339.74	236.88	201.83	164.61	187.21
	(0.94)	(5.85)	(2.35)	(1.73)	(1.28)	(4.58)	(3.19)	(3.10)	(3.15)	(3.68)
OPN (%)	0.39	-0.01	2.30	1.01	0.57	1.19	0.41	-0.20	0.24	0.60
	(0.58)	(-0.05)	(4.12)	(3.02)	(1.14)	(2.80)	(1.93)	(-0.79)	(0.99)	(2.35)
PTRB (1995US$)	-0.28	-0.11	-0.08	-0.05	-0.31	-0.01	-0.03	0.00	-0.00	-0.00
	(-0.74)	(-1.40)	(-2.85)	(-0.56)	(-2.80)	(-1.89)	(-0.25)	(0.14)	(-0.94)	(-1.34)
War	-29.18	-13.71	69.88	-54.12	-5.13	21.54	-39.48	-49.85	-2.13	42.08
	(-1.31)	(-0.72)	(2.80)	(-3.14)	(-0.21)	(0.49)	(-1.39)	(-1.85)	(-0.09)	(1.28)
AR(1)	0.89	0.93	0.94	0.89	0.81	0.94	0.85	0.89	0.85	0.95
	(19.89)	(56.24)	(58.93)	(41.31)	(24.20)	(40.41)	(23.62)	(35.41)	(40.38)	(67.68)
AdjR2	0.948	0.962	0.964	0.899	0.927	0.955	0.870	0.888	0.946	0.971
Log Likelihood	-737.7	-3226.6	-1867.1	-2684.7	-1370.4	-1419.4	-1227.8	-2305.9	-2533.6	-1694.8
F	527.94	2951.3	1582.1	838.0	475.9	1044.9	284.7	629.8	1519.8	2017.1

Significant at least at the .10 level
Insignificant at the .05 level

* Numbers in the table are coefficients. Numbers in parenthesis under coefficients are statistical t-values for each estimator.

Table 3. Elasticity of the impact of each factor

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	OPEC
PDFP (cal/day)	.285	.081	.062	.087	.046	.034	.181	.082	.086	.096
LnPGDP (1995US$)	.043	.143	.078	.053	.044	.138	.110	.089	.066	.076
OPN (%)	.004	.000	-.003	-.000	-.002	-.002	-.000	.000	-.001	-.001
PTRB (1995US$)	.009	-.000	.031	.025	-.013	.029	.016	-.008	.008	.015

Significant at least at the .10 level
Insignificant at the .05 level

(3) OPN has significantly positive effects in some groups but does not have them in the other groups. PTRB does not have significant effect on Pcal except Group 3 and Group 5[22]. Even in the OPEC countries, where several of them had seen the drastic rise in PTRB through the mid-70s to the beginning of 80s, PTRB has not significantly affected Pcal. In Group 3 and Group 5, PTRB seems to have a rather negative impact on Pcal.

(4) The existence of civil war (WAR) does not have significant effect except group 3, group 4.

2. INTERPRETATION OF THE RESULT

2-1. Per capita domestic food production

Per capita domestic food production (PDFP) seems to be the most important factor to improve Pcal, since PDFP is the only factor which is significant in all the groups regardless of the agricultural population ratios. This means that even in the countries where more than half of the population is non-agricultural population and pure consumers of food, the increase in the domestic food production has led to the improvement of Pcal.

In large population groups and medium population groups, the impact of PDFP seems to become stronger and more significant as the agricultural population ratio rises. As was hypothesized in the previous chapters, Table 3 indicates that PDFP impacts Pcal to a larger extent and more significantly in large population groups than medium population groups.

[22] In Group 6, it is significant at the .10 level.

2-2. Economic growth

Economic growth seems to have positive effect on Pcal in many groups, especially groups with lower agricultural population ratios. This result suggests that an increase in per capita GDP, more broadly economic growth, should be considered as an important factor to improve Pcal when significantly large proportions of population are not engaged in the agricultural industry and thus pure food consumers.

However economic growth is not as significant as PDFP, especially in countries with high agricultural population ratios. In other words, per capita GDP may not improve Pcal if significantly large portions of population, for example more than 75% in this analysis, are engaged in the agricultural industry and thus most of them are engaged in food production.

It is assumed that the significance of effect of per capita GDP on Pcal is less clear in countries with high agricultural population ratios. The higher agricultural population ratio suggests that the agricultural industry is composed more of subsistence farmers in which farmers produce food for their own consumptions on the farms, and those farmers depend less on the food coming from the market outside. It can be noticed that, under this system, Pcal is affected more by a farmer's own per capita food production level, rather than their purchasing powers. Some countries with high agricultural population ratios and with the decreasing Pcal, such as Kenya and Burundi, have actually seen growth in their per capita GDP.

2-3. Trade liberalization

The openness of the domestic market (OPN) and per capita trade balance (PTRB) seem to have significant effects on Pcal in some groups. However, the impacts of these two factors are not commonly significant, and are not strongly related with the agricultural population ratio and the population size.

In groups where OPN is significantly positive, OPN may have contributed to the rise in Pcal in two ways. In one way, OPN has accelerated economic growth which has increased the purchasing power for the food in either the domestic market of the international market. In another way, OPN may have directly contributed to the growth in domestic food production through the increasing imports of production input materials. In the latter path, economic growth may not be as evident as the domestic food production growth. Considering that LnPGDP has less significant impact on Pcal in Group 4 compared with Group 3, 6 and the OPEC countries, OPN has contributed to Pcal increase more through the increasing demand for food in Group 3 and 6, and more through the increasing productivity in Group 4. The impact of OPN in the OPEC countries may be similar to those in Group 3 and 6; however the impact of PDFP in the OPEC countries is stronger and more significant than in Group 3 and 6. The impact of OPN on Pcal is unclear in the other groups.

The impact of PTRB on Pcal is commonly weak and unclear, and is not significantly positive in any group. The weak relationship between PTRB and Pcal can be explained by the following reasons. (1) Even though a large part of the increase in Pcal in 1970s had come from increasing net food imports except in Indonesia, some countries like Iran, Saudi Arabia, Ecuador and Indonesia had succeeded in raising or maintaining Pcal by

increasing PDFP, in spite of the generally declining PTRB during 1980s. Some OPEC countries with large populations, for example Indonesia, the large surpluses in trade balances might have largely been offset by their population sizes. (2) Countries such as Angola, Botswana, Republic of Congo and Papua & New Guinea, have not seen significant improvements in their Pcal even though their PTRB have generally been highly positive. Angola, Botswana and Republic of Congo had all seen significant declines in their PDFP through 1970s to the present.

The result in Group 5 suggests that PTRB may lower Pcal. PTRB can have negative impact on Pcal if the creation of the large surplus in PTRB is accompanied by the significant decline in PDFP. In other words, Pcal can decline if a large part of resources, such as lands, capitals and labors, are shifted to the non-food productions, even if the consequent increase in PTRB can increase the food imports.

It is implied that trade liberalization does not clearly contribute to the improvement in Pcal compared with the contribution of the domestic food production growth and economic growth.

2-4. Political unrest

The existence of civil war probably had negative impact on Pcal in Group 4. It is significantly positive in Group 3. However the impact is generally insignificant.

The possible reason of this insignificance is that the condition under civil war such as the severeness or the frequency of fighting and its effect on food production or the

economic activity vary rather than stay at the same level. Therefore the dummy variable may be unable to accurately describe those conditions[23].

3. OVERALL IMPLICATION FOR THE ALLEVIATION OF SEVERE FOOD INSECURITY

3-1. Overall implication

In large population and medium population groups, it seems that Pcal is affected by more factors as the agricultural population ratios decline. In large population groups, Pcal is affected only by PDFP in Group 1, by PDFP and LnPGDP in Group 2, and by PDFP, LnPGDP and OPN in Group 3. In medium population groups, even though it is not as clear as large population groups, the impact of PDFP on Pcal becomes weaker and the impacts of LnPGDP and OPN on Pcal become relatively stronger as the agricultural population ratio declines. This result implies that the impacts of domestic food production, economic growth and trade liberalization on Pcal vary according to the agricultural population ratio of the country. More precisely, the higher a country's agricultural population ratio is, the stronger the impact of domestic food production is and the weaker the impacts of economic growth and trade liberalization are. Conversely, as the agricultural population ratio declines, the impact of the domestic food production

[23] In Group3, most of the countries which have experienced civil war had increased the net food import and food supply from stock at the beginning year of the period of civil war. Per capita GDP level at the time of war was significantly different between these countries and the other countries like many of African countries with civil war. Countries with the low per capita GDP had their Pcal affected mainly by PDFP. For example, Nigeria, one of the OPEC countries with the significantly low per capita GDP has had several years of the civil war. However Nigeria's Pcal during the civil war seems to have been affected mainly by PDFP, regardless of the existence of the civil war.

growth becomes weaker and less significant even though it is still significantly positive, and the impacts of economic growth and trade liberalization become stronger and more significant.

These implications to some extent conform to the conceptual framework in Chapter 3.

A higher agricultural population ratio indicates that the domestic food production growth can enhance the income level and thus the purchasing power of the majority of a country's population, and can also significantly increase the food consumption level of subsistence farmers who may comprise the large portion of the population.

As the non-agricultural population ratio rises, the ratio of pure food consumers increases. Under this shift, the impact of the income level on Pcal becomes stronger. This is because the proportion of the subsistence food consumption may decline and the foodstuffs are consumed more through the market, in which individual's income level as the purchasing power determines the food consumption level.

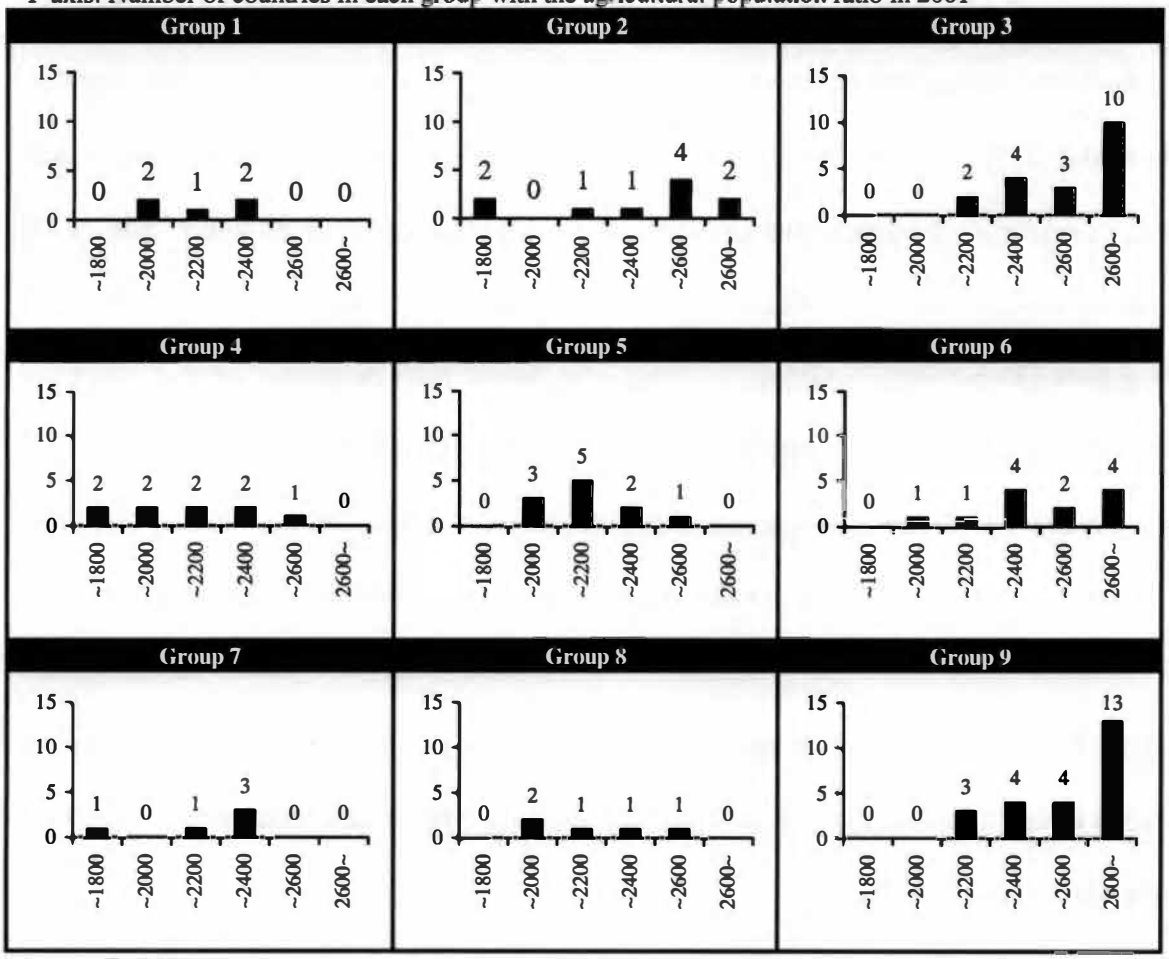
3-2. The implication for the countries with severe and widespread food insecurity

The more severe food insecurity today generally exists under specific agricultural population ratios and population sizes. Table 4 presents the distribution of countries based on the agricultural population ratio and the population size in 2001, and respective Pcal level through 1997~2001. Figure 1 shows the cumulative distribution of countries, in which countries with more than 50 percent of agricultural population ratio are categorized into Group1, 5 and Group2, 4, 7 and 8, since PDFP is the only significant positive factor for Pcal in Group 1 and 5.

Table 4. Distribution of countries among groups in 2001

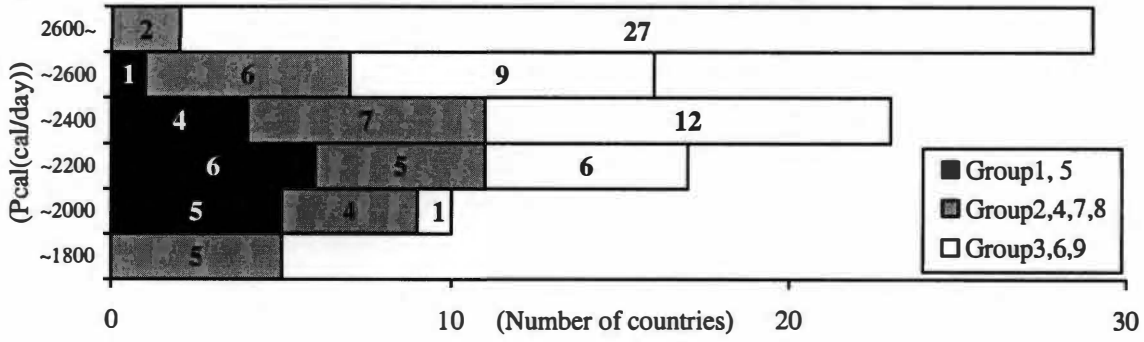
X-axis: Per capita calorie intake level (average through 1997~2001) (cal/day)

Y-axis: Number of countries in each group with the agricultural population ratio in 2001



Source: FAOSTAT

Figure 1. Cumulative distribution of countries among groups



Source: FAOSTAT

Figure 1 illustrates that countries with low Pcal today are more distributed in group with more than 50 percent of the agricultural population ratio. It is shown that fifteen out of sixteen countries (94 percent) in Group 1 and 5 have Pcal of lower than 2,400 cal/day. In Group 2, 4, 7 and 8, although the proportion is lower than in Group 1 and 5, still twenty-one out of twenty-nine countries (72 percent) have Pcal of lower than 2,400 cal/day. On the other hand, Pcal is below 2,400 cal/day in only nineteen out of fifty-five countries (35 percent) in Group 3, 6 and 9, in which both economic growth and trade liberalization seem to have significantly positive impact on Pcal. It generally takes time for a country to decline its agricultural population ratio. Therefore, it is not expected that countries in high agricultural population ratio will soon go into the category of the lower agricultural population ratio. Therefore domestic food production should be highlighted more than economic growth and trade liberalization in the process of improving per capita calorie intake level, especially in the countries with severe food insecurity and the widespread undernutrition.

CHAPTER 6

SUMMARY AND CONCLUSION

1. OVERALL SUMMARY

Many factors need to be taken into consideration to identify effective solutions for the improvement of food security. These factors can be explained by economics, politics, the environmental issues, or something else besides domestic food production level. Food security has been more and more recognized as multifaceted problem (FAO, 1996a), rather than simply the matter of the amount of food supply and population. Food security has been approached from wider variety of aspects than it was in the past, with increasing numbers of factors having been recognized as the forces that possibly affect food security (Maxwell, 1996). One of the aspects with the increasing attention is related with the social and economic environments, mainly represented by economic growth and trade liberalization.

Food security can presumably be improved not only by the domestic food production growth but also by economic growth and by trade liberalization. Policymakers have been provided with more options to choose to improve food security, as economic growth and trade liberalization become increasingly recognized as the effective ways to improve food security. To have more policy options to improve food security would be a better situation for a government rather than to have the domestic food production growth as the only one option. The promotion of economic growth and trade liberalization set out in the Rome Declaration can therefore be considered desirable.

The primary objective of this research was to compare the significances of the impacts of these three factors on the improvement of a country's per capita calorie intake level, and how the relative significances would change based on the agricultural population ratio and the population size of the country. The concept of per capita calorie intake level to some degree, though not perfectly, reflects food security at each of national level, household level and individual level. The result of this research was therefore expected to provide policy makers with certain extent of the insight into the most effective way to improve food security at these three levels.

Results of this research clearly suggest that the impacts of these three factors vary under different characteristics of the country. They also suggest that one policy improves food security more efficiently than other two policies do, under specific characteristics of the country. Overall, results of this research emphasize the importance of the identification of the most effective policy among three aforementioned policies to improve food security.

One indication about the identification of the most effective policy was given about the domestic food production. Results of this research imply that domestic food production growth is an important factor to improve food security regardless of the agricultural population ratio and the population size of a country. It is also implied that a large part of food insecurity today exists under a situation in which the domestic food production growth is more exclusively the key factor to improve per capita calorie intake level, if compared with economic growth and trade liberalization.

2. THE LIMITATION OF THIS RESEARCH

The limitations of this study are related with the data, the method of the grouping of countries, and the model.

Even though the usage of the data of national average was justified in chapter 3, it is not assured that the improvement in Pcal always means the same degree of the improvement in individual inhabitants' per capita calorie intake level. Since this research is based on the national average data, although the result may be useful for the improvement of food security at national level, more precise and thorough research is necessary to be useful for the policies directed toward the improvement of food security at household or individual level.

The results of this research may be influenced by the criteria by which countries are selected and grouped. Some countries may be added or dropped if different criteria are used. Therefore the results may change significantly.

The same model was used for all the groups in order to facilitate the comparison of the significance of the impacts of each factor. This may ignore the possibility that the suitable model for each group is different.

3. SUGGESTION FOR FUTURE RESEARCH

The model can be more accurately specified by including more factors which presumably affect Pcal. The domestic food production, economic growth and trade liberalization may not be the only factors.

The model specification with the random effects model instead of the fixed effects model can be interesting.

The relationship between the agricultural population ratio and the degree of subsistence in the farmer's food consumption should be tested. The result of the test will be useful to examine the accuracy of the implication of the result of this research.

A theoretical background can be established. The empirical data imply that domestic food production is generally significant factor to affect food security and becomes a more exclusive factor under a higher agricultural population ratio and a larger population size. The results of this research based on the empirical data may suggest that the per capita calorie intake level has been able to be improved mainly by the growth of per capita domestic food production. Thus it indicates that food security can be improved by mainly developing the domestic food production level in the countries with food insecurity today.

However, this result does not prove that this is the best way to improve food security and to solve the food insecurity problem. The result of this analysis may be highly affected by a specific economic system through the period of the analysis, and thus may be different under different economic systems. For example, although the results of the research imply that the impact of trade liberalization may be weaker than domestic food production, it is not clear whether this result is because trade liberalization can not contribute to the improvement of food security, or simply because trade liberalization had not been so common during the period of the analysis. The latter possibility can not be denied since it is true that the trade of most of the agricultural commodities had not been significantly liberalized until recently. Under this circumstance, the result of this research may not be applicable in the future if trade liberalization is going to be highly promoted

worldwide. The establishment of a theoretical background can therefore be helpful to examine the universality and consistency of the implication of this analysis.

REFERENCE

REFERENCE

Agcaoili-Sombilla, Mercedita and Mark W. Rosegrant, 1996. "South Asia and the global food situation: Challenges for strengthening food security". *Journal of Asian Economics*, Pages 265-292.

Alexandratos, Nikos, 1995. "World agriculture: Towards 2010." Food and agriculture organization of the United Nations.

Ballenger, Nicole and Carl Mabbs-Zeno, 1992. "Treating food security and food aid issues at the GATT." *Food policy*, Pages 264-276.

Baltagi, Badi H., 2001. "Econometric analysis of panel data; second edition"

Barrett, Christopher B., 1997. "Food marketing liberalization and trader entry: Evidence from Madagascar." *World Development*, Vol.25, No.5, Pages 763-777.

Bruck, Tilman, 2001. "Determinants of rural poverty in post-war Mozambique: Evidence from a household survey and implications for government and donor policy." *QEH Working Paper Series*. Oxford: Queen Elizabeth House. **67**.

Cheru, Fantu, 1992. "Structural adjustment, primary resource trade and sustainable development in sub-Saharan Africa." *World Development*, Vol. 20, Issue 4, Pages 497-512.

Cour, Jean Marie, 2001. "The Sahel in West Africa: countries in transition to a full market economy." *Global Environment Change*, Volume 11, Pages 31-47.

Diaz-Bonilla, Eugenio, Sherman Robinson, 2001. "Shaping Globalization for Poverty Alleviation and Food Security." Focus 8, Policy Brief, International Food Policy Research Institute.

Diaz-Bonilla, Eugenio, Marcelle Thomas, Sherman Robinson, Andrea Cattaneo, 2000. "Food Security and Trade Negotiations in the World Trade Organization: A Cluster Analysis of Country Groups." The discussion paper No.59, Trade and Macroeconomics Division, International Food Policy Research Institute.

Dione, J., 1989. "Informing Food Security Policy in Mali: Interactions Between Technology, Institutions and Market Reforms." Unpublished PhD Dissertation, Michigan State University, East Lansing, MI.

Dorosh, Paul A. 2001. "Trade liberalization and national food security: Rice trade between Bangladesh and India." *World Development*, Vol.29, Pages 673-689.

Duncan, Alex, 1998. "The food security challenge for southern Africa." *Food Policy*, Vol.23, No.6, Pages 459-475.

Eicher, C.K. and Rukuni, M. 1994. "Zimbabwe's Agricultural Revolution." University of Zimbabwe Press, Harare, Zimbabwe.

FAO, 2003. "Trade reforms and food security; conceptualizing the linkages". Commodity policy and projections service, Commodities and Trade division. (http://www.fao.org/DOCREP/005/Y4671E/y4671e00.htm#Contents)

FAO, 1996a. "Rome Declaration on World Food Security and World Food Summit Plan of Action, Rome."

FAO, 1996b. "Socio-political and economic environment for food security". Technical Background Documents 3 submitted for the World Food Summit, Rome in 1996.

FAO, 1996c. "Food security and nutrition". Technical Background Documents 5 submitted for the World Food Summit, Rome in 1996.

FAO, 1996d. "Food and international trade". Technical Background Documents 12 submitted for the World Food Summit, Rome in 1996.

Fleuret P. and Fleuret A., 1991. "Social organization, resource management, and child nutrition in the Taita Hills, Kenya." *Am. Anthropol.* **93**, Pages 91-114.

Flores Palacios X, 1997. "Contribution to the Estimation of Countries' Interdependence in the area of plant genetic resources" Commission on Genetic Resources for Food and Agriculture, Rome.

Foster, Phillips Wayne, 1992. "The world food problem: Tackling the causes of undernutrition in the Third World." Lynne Rienner, Boulder, Co.

Geweke, John, 1997. "An empirical analysis of income dynamics among men in the PSID: 1968-1989." Institute for Research on Poverty, Discussion Paper no. 1127-97. (http://www.ssc.wisc.edu/irp/pubs/dp112797.pdf)

Govereh, J., and Jayne, T.S., 2003. "Cash cropping and food crop productivity: synergies or trade-offs?" *Agricultural Economics*, Vol. 28, Issue 1, Pages 39-50.

Gladwin, Christina H., Anne M. Thomson, Stirling, 2001. "Food or cash crops: Which is the key to food security",

Greenfield, Jim, Maurizio de Nigris, Panos Konandreas, 1996. "The Uruguay Round Agreement on Agriculture: food security implications for developing countries." *Food Policy*, Vol.21, Pages 365-375.

Hausman, J.A., 1978. "Specification tests in econometrics." *Econometrica* 46, Pages 1251-1271.

Haaga J., Mason J., Omoro F.Z., Quinn V., Rafferty A., Test K. and Wasonga L., 1986. "Child malnutrition in rural Kenya. A geographic and agricultural classicification." Ecol. Food Nutrition, **18**, Pages 297-307.

Hazell, P.B.R. & Ramasamy, C. 1991. "The green revolution reconsidered. The impact of high-yielding rice varieties in South India." Baltimore, MD, USA and London, UK, Johns Hopkins University Press, for IFPRI.

Hjelm, Göran, 2000. "Is private consumption growth higher (lower) during periods of fiscal contractions (expansions)?" *Journal of Macroeconomics*, Vol. 24, Issue 1, Pages 17-39.

Hufbauer, Gary C., Reginald Jones and Barbara Kotschwar, 1998. "The future course of trade liberalization." *Paper for the world bank challenges for the twenty-first century, October 1998.* Institute for International Economics.

Ingco, Merlinda D., Donald O. Mitchell, Alex F. McCalla, 1996. "Global Food Supply Prospects. –A Background paper prepared for the world food summit, Rome, November 1996". World Bank Technical Paper No.353.

Josling, Tim and Barichello, Richard, 1984. "International trade and world food security. The role of developed countries since the World Food Conference." *Food policy*, Vol. 9, Issue 4, Pages 317-327.

Kostov, Philip and Lingard, John, 2002. "Subsistence farming in transitional economies: lessons from Bulgaria." *Journal of rural studies*, Vol. 18, Issue 1, Pages 83-94.

Lipton, Micheal, 1975. "Urban bias and food policy in poor countries." *Food Policy*, Vol.1, No.1, Pages 41-52.

Maasdorp, Gavin, 1998. "Regional trade and food security in SADC." *Food policy*, Vol.23, Pages 505-518.

Marchione, Thomas J., 1996. "The right to food in the post-Cold War era." *Food policy*, Vol. 21, Issue 1, Pages 83-102.

Maxwell, Simon, 1996. "Food security: a post-modern perspective", *Food policy*, Vol. 21, Pages 155-170

Maxwell, S. & Smith, M. 1992. "Household food security; a conceptual review". *In* S. Maxwell & T.R. Frankenberger, eds. *Household Food Security: Concepts, Indicators,*

Measurements: A Technical Review. New York and Rome: UNICEF and IFAD.

McMichael, Philip 1993. "World food system restructuring under a GATT regime." *Political Geography*, Vol.12, Pages 198-214.

Mellor, John W., 1988a. "Global food balances and food security." *Food policy*, Vol.16, Pages 997-1011.

Mellor, John W., 1988b. "Food policy, food aid and structural adjustment programmes. The context of agricultural development." *Food policy*, Pages 10-17.

Mellor, John W. and, Richard H. Jr. Adams, 1986. "The new political economy of food and agricultural development." *Food policy*, Pages 289-297.

Myhrvold-Hanssen, Thomas L., 2002. "Hunger, Private Property Rights, and the Right to Food." Working Paper Nr. 2002/2. University of Oslo.

Paarlberg, Robert 2000. "The weak link between world food markets and world food security." *Food Policy*, Vol.25, Pages 317-335.

Paulino, Leonardo A., Mellor, John W., 1984. "The food situation in developing countries. Two decades in review." *Food Policy*, Pages 291-303.

Payne, P.R., 1990. "Measuring malnutrition" in *IDS* Bulletin 21, No.3.

Plateau, Jean-Philippe, 1995. "Famine prevention in Africa: Some experience and lessons." In "The political economy of hunger: selected essays" by Drèze Jean, Amartya Kumar Sen, and Athar Hussain, 1995.

Poulton, Colin and Andrew Dorward, 2002. "Forum for food security in southern Africa: The role of market based economic development in strengthening food security." (http://www.odi.org.uk/Food-Security-Forum/docs/markets_final.pdf)

Per Pinstrup-Andersen, Rajul Pandya-Lorch, 2001. "Emerging food and agriculture concerns in the developing world."

Quantitative Micro Software LLC, "Eviews 4 user's guide". Pages 302, 645-648.

Raffer, Kunibert, 1997. "Helping southern net food importers after the Uruguay round: A proposal." *World Development*, Vol.25, No.11, Pages 1901-1907.

Ramanathan, Ramu, 2002. "Introductory econometrics with applications: Fifth edition" Harcourt College Publishers.

Richards, Alan, 1991. "Syrian food security in the 1970s and 1980s." *Food policy*, Pages 487-492.

Rooyen, Johan Van, Howard Sigwele, 1998. "Towards regional food security in southern Africa: a (new) policy framework for the agricultural sector". *Food policy*, Vol.23, No.6, Pages 491-504.

Rosset, Peter, 2002. "The world food summit: What went wrong?" Food First/Institute for food and development policy. (http://www.foodfirst.org/media/opeds/2002/whatwentwrong.html)

Sandberg H. Mikael, Timothy G. Taylor, James L. Seale, Jr. "CARICOM bilateral trade: A preliminary analysis using the gravity model." International Agricultural Trade and Policy Center Technical Paper Series, 2002.

Sarris, Alexander H., 1980. "Grain imports and food security in an unstable international market." *Journal of Development Economics*, Vol. 7, Issue 4, Pages 489-504.

Seckler, David and Amarasinghe, Upali, 2000. "Water supply and demand, 1995 to 2025: water scarcity and major issues." In "World Water Supply and Demand: 1995 to 2025." International Water Management Institute. Colombo, Sri Lanka.

Sen, Amartya Kumar, 1981. "Poverty and famines: an essay on entitlement and deprivation." *Oxford University Press.*

Seshamani, V., 1999. "The impact of market liberalization on food security in Zambia." *Food policy*, Vol. 23, No.6, Pages 539-551.

Shane, Mathew, Lloyd Teigen, Mark Gehlhar, Terry Roe, 2000. "Economic growth and world food insecurity: a parametric approach". *Food policy*, Vol. 25, Issue 3, Pages 297-315.

South Centre, 1997. "Universal Food Security: Issues for the south".

Strasberg, P.J., 1997. "Smallholder Cash-Cropping, Food-Cropping and Food Security in Northern Mozambique." Unpublished PhD Dissertation, Michigan State University, East Lansing, MI.

Thomas C. Pinckney, 1993. "Is market liberalization compatible with food security? Storage, trade and price policies for maize in Southern Africa." *Food policy*, Vol. 18, Issue 4, Pages 325-333.

Thomson, Anne, and Manfred Metz. 1996. "Implications of Economic Policy for Food Security. A Training Manual". Agricultural Policy Support Service Policy Assistance Division. Rome: FAO.

Timmer, C. Peter, 2000a. "The macro dimensions of food security: economic growth, equitable distribution, and food price stability." *Food policy*, Vol.25, Pages 283-295.

Timmer, C. Peter, 2000b. "Getting agriculture moving: do markets provide the right signals?" *Food Policy*, Vol.20, No.5, Pages 455-472.

Timmer, C. Peter, 1989. "Food price policy – The rationale for government intervention" *Food policy*, Vol.14, Issue 1, Pages 17-27.

Tyers, Rodney and Rachman, Anas. 1982. "Food security, consumption diversification and foreign exchange balances in Indonesia: Results from a multi-commodity simulation." *Journal of policy modeling*, Vol.4, Issue 3, Pages 363-393.

United Nations, 2003. "Indicators for Monitoring the Millennium Development Goals; Definitions, Rationale, Concepts and Sources."

United Nations, 1948. "Universal Declaration of Human Rights." United Nations, General Assembly resolution 217 A (III) of 10.

United Nations Department of Economic and Social Affairs: Division of Sustainable Development, "Indicators of sustainable development: Guidelines and methodologies". (http://www.un.org/esa/sustdev/natlinfo/indicators/isdms2001/isd-ms2001isd.htm#economicstructure)

USAID, 1994. "Breaking the Cycle of Despair: President Clinton's initiative on the horn of Africa: Building a New Foundation for Food Security and Crisis Prevention in the Greater Horn of Africa". (http://www.usaid.gov/regions/afr/ghai/annex_b.htm)

USDA, 1999. "Food Security Assessment". USDA Economic Research Service. Situation and Outlook series GFA-11 Washington DC

Wansbeek, Tom, 1992. "Transformations for panel data when the disturbances are autocorrelated." *Structural Change and Economic Dynamics*, vol. 3, no. 2, 1992.

William, H. Greene, 1998. "Limdep - Version 7.0 - User's manual - Revised Edition." Econometric software, Inc.

Woodhouse, Philip 1989. "From green revolution to food security in sub-Saharan Africa." *Food policy*, Pages 7-12.

World Bank, 1986. "Poverty and Hunger: Issues and options for food security in developing countries." Washington, DC.

APPENDICES

APPENDIX A. Commodity list

Table 5. Commodity list

Commodity				
Grain				
Wheat	Rice	Barley	Maize	Rye
Oats	Millet	Sorghum	Grain, other	
Starchy Roots				
Cassava	Potatoes	Sweet Potatoes	Yams	Roots, other
Sugar crops				
Sugarcane		Sugar beet		
Sweeteners				
Sugar (Non centrifugal)	Sugar	Sweetener, other	Honey	
Pulses				
Beans	Peas	Pulses, other		
Tree nuts				
Oil crops				
Soybeans	Groundnuts	Sunflowerseed	Rape & Mustard seed	Cotton seed
Coconuts	Sesame seed	Palm kernels	Olives	Oil crops, other
Vegetable oils				
Soybean oil	Grountnuts oil	Sunflowerseed oil	Rape&Mustardseed oil	
Cottonseed oil	Palmkernel oil	Palm oil	Sesameseed oil	
Olive oil	Ricebran oil	Maize Germ Oil	Oil crops, oil, other	
Vegetables				
Tomatoes	Onions	Vegetable, other		
Fruits excluding wine				
Oranges	Lemons	Grapefruit	Citrus	
Bananas	Apples	Plantains	Pineapples	
Dates	Grape(excl.Wine)	Fruits, other		
Stimulants				
Coffee	Cocoa beans	Tea		
Spices				
Pepper	Pimento	Cloves	Spices, other	
Alcoholic Beverages				
Wine	Beer	Beverage, Fermented	Beverage, Alcoholic	
Meat				
Bovine	Mutton, Goatmeat	Pigmeat	Poultry meat	Meat, other
Offals				
Animal fats				
Butter, Ghee	Fats, animal	Fish, body oil		
Milk		**Eggs**		
Fish, Seafood				
Freshwater fish	Demersal fish	Pelagic fish	Marine fish, other	
Crustaceans	Cephalopods	Molluscs, other		
Aquatic Products, other				
Aquatic Animals, other		Aquatic Plants		

Source: FAOSTAT

APPENDIX B. PDFP calculation

Exception in the formula of PDFP

Exceptional method is applied for some commodities (Commodity list is on **Table 6**). These commodities are unique since the FAOSTAT treat them as different products even if one of the two commodities is the processed commodity of the other. In the FAOSTAT, the supplies of these processed commodities are described by the same categories as their raw materials, such as the domestic productions, the imports, the exports and the stock changes.

This method is not appropriate when used to calculate the per capita domestic food production in this research. For example, a country may produce soybean oil totally domestically, from all imported soybean. In this case, it seems that calorie supply in the shape of soybean oil comes from domestic production according to the method described in the research. However, since all soybeans are imported from abroad, it is more appropriate to consider that calorie is totally imported. In some countries large part of the raw material from which another commodity is processed is supplied largely by the import. Thus the contribution of the domestic production on calorie supply from processed products becomes weaker.

The exact proportion between domestic production and the import of raw materials, with which oil products are domestically produced, is not accurate due to the unavailability of data; therefore certain assumption must be applied in the calculation.

In this research, it is calculated as follows:

Suppose domestic production of a processed product i is composed of a raw material r domestically produced, supplied from stock, and imported.

$$DP_{it} = DPd_{it} - DPx_{it} + DPs_{it} + DPm_{it}$$

DP_{it} = Domestic production of i
DPd_{it} = Domestic production of i based on domestically produced r in the same year
DPx_{it} = Imaginary domestic production of i based on exported r in the same year
DPs_{it} = Domestic production of i based on r provided from stock
DPm_{it} = Domestic production of i based on imported r

DPd_{it}, DPx_{it}, DPs_{it}, DPm_{it} are assumed to be as follows respectively:

$$DPd_{it} = d_{rt} / (d_{rt} - x_{rt} + s_{rt} + m_{rt}) * DP_{it}$$

$$DPx_{it} = x_{rt} / (d_{rt} - x_{rt} + s_{rt} + m_{rt}) * DP_{it}$$

$$DPs_{it} = s_{rt} / (d_{rt} - x_{rt} + s_{rt} + m_{rt}) * DP_{it}$$

$$DPm_{it} = m_{rt} / (d_{rt} - x_{rt} + s_{rt} + m_{rt}) * DP_{it}$$

Table 6. Commodities with the exceptional PDFP

Processed Commodity	Raw materials
Sugar	Sugar Cane, Sugar Beet
Soybean oil	Soybean
Groundnuts oil	Groundnuts
Sunflowerseed oil	Sunflowerseed
Rape and Mustard seed oil	Rape and Mustard seed
Cottonseed oil	Cottonseed
Palmkernel oil	Palmkernel
Sesameseed oil	Sesameseed
Olive oil	Olives
Ricebran oil	Rice
Maize germ oil	Maize
Wine	Grape
Beer	Barley

Source: FAOSTAT

where d_{rt} tones of r is domestically produced, x_{rt} tones of r is exported from the domestic production d_{rt}, s_{rt} tones of r is provided from stock and m_{rt} tones of r is imported.

Here it is assumed that export of oil products is provided all by domestic production and none of the imported oil products would be exported. In the same way, it is assumed that imported raw materials account for certain proportion of the total raw materials even in the situation where net import of raw material is negative meaning more export than import of that raw material.

According to this definition, domestic production of oil products from calorie perspective must be DPd_{it}, not DP_{it}.

Under the assumptions and concepts mentioned above, the PDFP for these commodities are described as follows:

$$PDFP_{it} = Pcal_{it} * DPd_{it} / (F_{it} + NF_{it})$$

In case of livestock products, however, this exception in calculation is not applied since it is difficult to figure out the kinds and amounts of crops which are used as fodder for each livestock product.

APPENDIX C. Pcal and the undernourished population ratio

The United Nations describes the prevalence of undernutrition as the proportion of the population below minimum level of dietary energy consumption (United Nations, 2003). It is defined as the percentage of the population whose food intake falls below the minimum level of dietary energy requirements. According to the United Nations, this percentage is computed using the total food availability, the inequality in access to food and the dietary energy needed by different age and gender groups. Therefore, the prevalence of the undernutrition in each country is computed by a more complex combination of factors rather than simply by Pcal. In other words, it needs to be tested whether it is appropriate to use Pcal as an indicator for the prevalence of the undernutrition.

The comparison of Pcal and the undernourished population ratio (%) can help examine how accurately Pcal can represent the prevalence of the undernutrition in each country.

The correlation coefficient between these two indicators is -0.909. Therefore, it is assumed that these two indicators have significantly strong relationship.

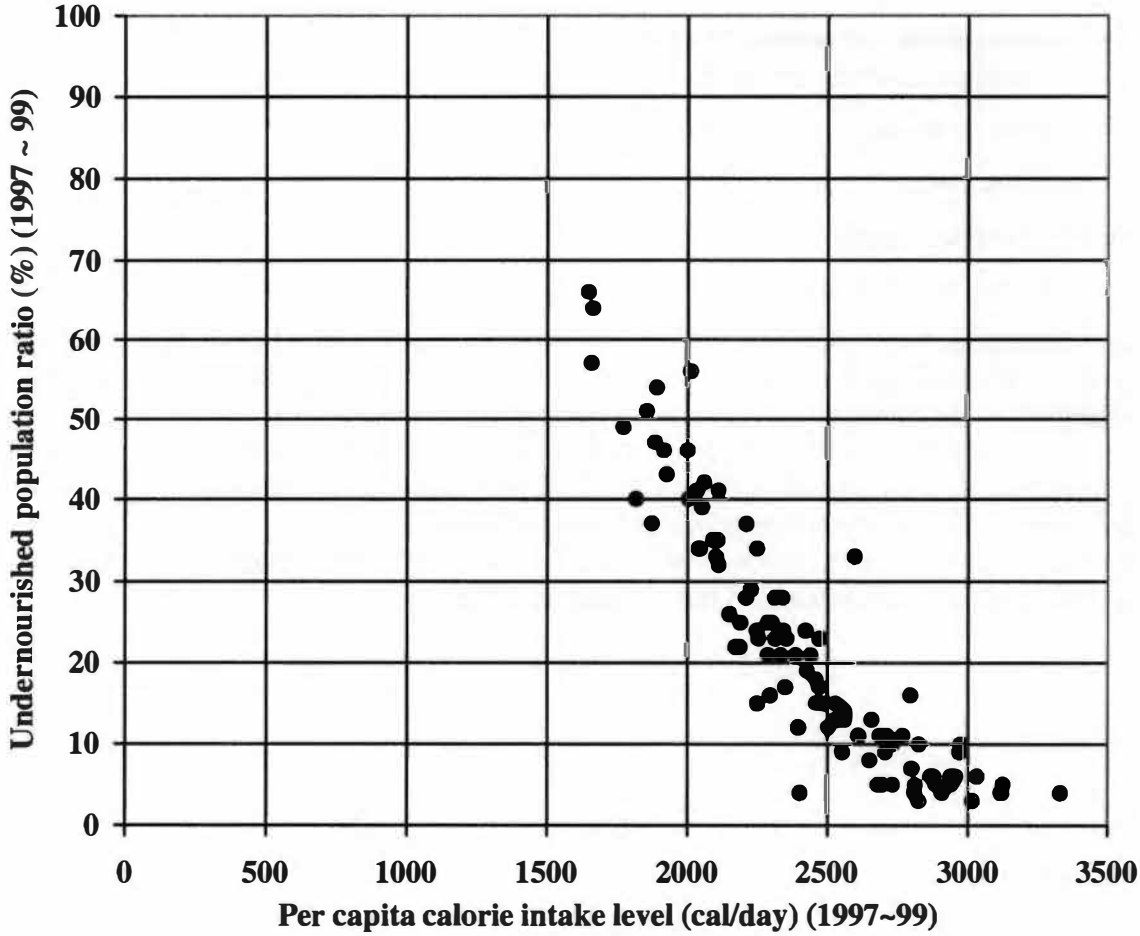
The Logit model estimates the following relationship between country's undernutrition level and Pcal during 1997~99:

Equation 1. Pcal and Undernourished population ratio

$$Y_i = 1 / [1 + e \text{ ^ } (- 4.793 + 0.0026 X_i)]$$

where Y_i describes undernourished population ratio (%) and X_i denotes the Pcal in country i. The relationship and estimated undernourished population ratio is illustrated in **Figure 2**.

Figure 2. Pcal and undernourished population ratio[24]



Source: FAOSTAT, World Bank

[24] Undernourished population ratio data were obtained from Human Development Report 2001, United Nations Development Program, as the average level through 1997 to 99. Per capita calorie intake level was calculated as the average through 1997 to 99 to maintain consistency.

APPENDIX D. The estimation of the model with AR(1) term

The estimation of AR term by Eviews

To estimate an AR(1) model, Eviews transforms the linear model

$$y_t = \alpha + x_t'\beta + u_t$$

$$u_t = \rho\, u_{t-1} + \varepsilon_t$$

into the nonlinear model,

$$y_t = \rho\, y_{t-1} + (x_t - \rho\, x_{t-1})\,'\beta + \varepsilon_t,$$

by substituting the second equation into the first, and rearranging terms. The coefficients ρ and β are estimated simultaneously by applying a Marquardt nonlinear least squares algorithm to the transformed equation (Eviews 4 user's guide).

The maximum number of the iterations and the convergence criterion are set unchanged from the original default value set by Eviews, i.e. the maximum number of the iterations is 50, and the convergence criterion is 0.0001.

See Eviews 4 user's guide *p*.645-656 for more detailed explanation of Marquardt method and the measurement of the convergence test.

VITA

Hiroyuki Takeshima was born in Tokyo, Japan on December 7th, 1979. He is the only son of Yoshihiro Takeshima, and Hiroko Takeshima. He graduated from Ryogoku Metropolitan High School at Tokyo, Japan, in 1998. The following April he entered the University of Tokyo in Tokyo, Japan. He received Bachelor of Economics in March, 2002.

He entered the University of Tennessee at Knoxville, Tennessee, in August 2002 in the Master of Science program in Agricultural Economics Department. He was awarded a position of the Graduate Research Assistant in July, 2003. He completed the Master of Science degree in August, 2004.

The author is a member of the Honor Society of Agriculture, Gamma Sigma Delta since November, 2003.

After his graduation he will accept a position of Graduate Research Assistant at the University of Illinois at Urbana-Champaign, Urbana, Illinois, to pursue a Doctor of Philosophy degree in Agricultural and Consumer Economics.

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