NORTH KOREAN FOOD SUPPLY AND DEMAND: AN ECONOMETRIC ANALYSIS

YOUNGJAE LEE
Department of Agricultural Economics and Agribusiness
Louisiana State University AgCenter
101 Agricultural Administration Building
Baton Rouge LA 70803-5606
Phone: 225-578-2722
Fax: 225-578-2716
E-mail: ylee@agctr.lsu.edu

P. LYNN KENNEDY
Department of Agricultural Economics and Agribusiness
Louisiana State University AgCenter
101 Agricultural Administration Building
Baton Rouge LA 70803-5606
Phone: 225-578-2726
Fax: 225-578-2716
E-mail: lkennedy@agctr.lsu.edu

BRIAN HILBUN
Department of Agricultural Economics and Agribusiness
Louisiana State University AgCenter
101 Agricultural Administration Building
Baton Rouge LA 70803-5606
Phone: 225-578-0345
Fax: 225-578-2716
E-mail: bhilbun@agctr.lsu.edu

Poster prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA, CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010

NORTH KOREAN FOOD SUPPLY AND DEMAND: AN ECONOMETRIC ANALYSIS

YOUNGJAE LEE, P. LYNN KENNEDY, BRIAN HILBUN

This study simulates North Korean food supply and demand using an econometric regression based upon neo-classical economic theory. In doing so, this study at first describes the autarky condition that exists in the closed economy of North Korea and the relationship between pro-military oriented economic policy and deficiency in the dietary needs required by the average North Korean. This study then quantifies the impact agricultural resources and policy have had on the production of food for the sample period of 1995 to 2008. Results show that food production decreases along with a decrease in agricultural input factors and with the implementation of a more pro-military oriented economic policy. Finally, this study simulates ex ante food balance. In order to meet food demand, the rate at which agricultural input factors are made available should be much more greater than the increasing rate of population, regardless of whether pro-market oriented economic policy reforms are implemented or not. And if a more pro-market approach is implemented by North Korea, the food balance appears to recover more quickly from food deficiency to food surplus given a specific level of agricultural resources.

Although there has much political criticism about the deteriorating food situation in North Korea over the eighteen year span from 1995 to 2008, no traditional economic analysis of North Korean food supply and demand has been conducted up to this point in time, as far as the authors are concerned. North Korea is one of the world's last centrally planned socialistic economies and is prominently isolated from the world economy. Empirically, food economists usually experience great difficulty in obtaining economic data for a country. This difficulty in data acquisition seems to be the main reason behind the paucity of economic analysis on North Korean food supply and demand. In the guise of political rhetoric, economists have seemed purposely to avoid doing those things which they *could* do. In fact, the North Korean government has been intensifying a pro-military oriented approach to economic policy since the mid-1990s when the food crisis initially broke out. This policy takes available resources and moves them from the civilian economic sector to the military in North Korea. This movement of resources has resulted in a decrease in available resources for the North Korean agricultural sector. Also, this policy has possibly contributed to exacerbating inefficiency in the North Korean agricultural sector than had been extant before because of further tightening resources for domestic agricultural production. This resource scarcity might leave the North Korean agricultural sector even more vulnerable to natural disasters because it restricted the

availability of labor and capital resources in time to mitigate those damages that occurred from natural disasters (i.e., floods and/or blight that had occurred in the 1990s). As a result, it is not an ambiguous point to conclude that a shift in policy priority has adversely influenced agricultural production in North Korea after the mid-1990s. Therefore, the intention of this study is to identify the empirical relationship between food production and government policy and resource scarcity using traditional econometric analysis. In doing so, this study will at first illustrate the equilibrium of the North Korean economy given resource and policy priority using modified neo-classical endowment theory. And then, this study goes on to explain how this equilibrium changes with the adoption of a pro-military oriented economic policy. This understanding (regarding military policy adoption for the N. Korean economy) will help the study to then develop an econometric model useful for empirical analysis and scheme simulation for the *ex ante* food balance in North Korea.

This study proceeds as follows. In the next section, this study will define the equilibrium condition of the North Korean economy as a closed economy. In doing so, this study will use modified endowment theory. Section three will show how pro-military oriented economic policy influences the equilibrium of the closed economy. In section four, this study will develop an econometric model so as to quantify the impacts pro-military oriented economic policy and agricultural input factors have on food production. For the model, a policy dummy variable and an input factor index will be used as explanatory variables for food production. North Korean food demand will be reviewed in section five. In this section, this study will briefly explain the public food distribution system in North Korea. And then, *ex post* food balance will be calculated for recent years. By using estimated parameters that were calculated in section four, this study simulates *ex ante* food balance that vary according to economic policy type and input factor availability. In the final section, a conclusion and attendant implications will be provided.

Autarky in the Closed Economy of North Korea

The ultimate goal of North Korean economic policy is construct an independent national economy.[1] According to this policy, the North Korean government has tried to minimize imports to the extent that for those imports which are allowed chiefly consist of goods which the North Korean economy needs but

is not equipped for their production. Exports are just a source of revenue for the purchase of needed imports. As a result, foreign trade's percentage share of North Korea's GDP is very small unlike that in most open economies (see Table 1).

[Place Table 1 Approximately Here]

The equilibrium of the closed North Korean economy can be drawn within the framework of a neo-classical endowment model. In order to do this, this study assumes the following: (1) the North Korean economy is demarcated into two groups: the military sector (non-civil industrial sector) and the civil industrial sector. Resources, including labor and capital, are endowed in both industries. Now, let us consider the North Korean economy that produces civil and non-civil goods, Q_C and Q_M, respectively, by using resources endowed in the civil and non-civil sectors. Input-output production functions for both Q_C and Q_M are defined as:

(1.1) $Q_C = A_C F_C(X_C)$

(1.2) $Q_M = A_M F_M(X_M)$

where Q_C is the quantity of civil goods produced, Q_M is the quantity of non-civil goods produced, X_C and X_M are the quantities of resources used to produce civil and non-civil goods, respectively. The factor productivity of the civil production function, (A_C), represents the efficiency of the civil industry and the factor productivity of the non-civil production function, (A_M), represents the efficiency of non-civil industry. Equilibrium condition of the input factors of the economy is written as

(2) $X = X_C + X_M$

where X is the total resource endowment in the economy. Equation (2) is the economy's equilibrium condition for resources endowed in both civil and non-civil industries. We can draw the economy's production possibility frontier (PPF), which shows alternative combinations of civil and non-civil goods that this economy can produce under equilibrium conditions in resources including labor and capital. Since these resources are not equally used in the production of civil and non-civil goods, the economy's

PPF is assumed to be concave from the origin. The PPF shows the maximum amount of civil and non-civil goods that this economy can produce with its given endowment of resources. When the North Korean economy produces civil and non-civil goods along the PPF, the North Korean economy is in equilibrium in regards to its resources. An absolute slope of the PPF represents the opportunity cost of producing a non-civil good in terms of a civil good. That is, the opportunity cost represents how many units of a civil good should be given up in order to produce one additional unit a non-civil good. Since the PPF is concave from the origin, the opportunity cost of non-civil good increases as more of a non-civil good is produced.[2]

The allocation of resources in producing civil and non-civil goods is optimal at any point on the PPF because the PPF represents the maximum quantity of civil and non-civil goods that the North Korean economy can produce with its given resources. Since the North Korean economy can maximize its social utility under the production constraint given by its PPF, equilibrium occurs at point *E* in Figure 1, where the PPF is tangent to the highest attainable social indifference curve (SIC) in the closed North Korean economy.

[Place Figure 1 Approximately Here]

Impact of Pro-military Oriented Policy on the Economy

In a socialist country, the government allocates resources according to its national goals that have been prioritized by a centrally determined economic policy. For example, the North Korean government allocates X_C to its civilian industrial sector and X_M to its non-civilian industrial sector according to the leadership's overall national objective. As is commonly known, the North Korean economy was faced with severe economic hardship after the collapse of the former Soviet Union from 1985 to 1991 and the death of the founder of North Korea in 1994. Since then, the North Korean government has intensified a pro-military oriented policy by which resources are disproportionately allocated to its non-civilian sector. This policy result is described in Figure 2.

[Place Figure 2 Approximately Here]

For a pro-military oriented economic policy, resources, including labor and capital, are moved from the civilian sector to the non-civilian sector. As a result, X_C decreases from X_C^0 to X_C^1 ($X_C^0 > X_C^1$), while X_M increases from X_M^0 to X_M^1 ($X_M^0 < X_M^1$). The factor productivity of the non-civilian sector increases with the increased investment in both labor and capital resources while the factor productivity of the civilian sector decreases with a decrease in the investment of both labor and capital. As a result, the civil production function rotates downward from Q_C^0 to Q_C^1, while the non-civil production function rotates upward from Q_M^0 to Q_M^1. With a pro-military oriented economic policy and with the following resource reallocation, the production possibility frontier changes from PPF_0 to PPF_1. The equilibrium of the North Korean economy also changes from (Q_C^0, Q_M^0) to (Q_C^1, Q_M^1), where military production increases from Q_M^0 to Q_M^1 while civilian production decreases from Q_C^0 to Q_C^1 given relative prices and social utility.[3]

Although social utility should be decreased by decreased civilian production and the diversion of labor into military service, this decrease in social utility will be compensated for if North Korean society feels more secure. Nevertheless, the extreme decrease in civilian goods like food will decrease social utility. For example, let us assume a utility function that satisfies both continuity and non-satiation conditions and write it as follows:

$$u = \frac{\dot{Q}_C^{\theta} + \eta \dot{Q}_M^{\gamma_1}}{\dot{Q}_M^{\gamma_2}}, \tag{3}$$

where $\theta > 0$, $\eta > 0$, $\gamma_1 > 0$, $\gamma_2 > 0$, $\gamma_1 > \gamma_2$, $\dot{Q}_C = \frac{Q_C}{\overline{Q_C}}$ is the normalized quantity for the civilian good, $\overline{Q_C} = \frac{1}{N}\sum_{i=1}^{n} Q_{iC}$, and $\dot{Q}_M = \frac{Q_M}{\overline{Q_M}}$ is the normalized quantity for the non-civilian good, $\overline{Q_M} = \frac{1}{N}\sum_{i=1}^{n} Q_{iM}$.

From equation (3), we can obtain the total marginal utility at the mean values of $\dot{Q}_C$ and $\dot{Q}_M$ is as follows:

(4) $$du = \theta d\dot{Q}_C + \eta(\gamma_1 - \gamma_2)d\dot{Q}_M .$$

Since an increase in the production of the non-civilian good causes a decrease in the production of the civilian good, the marginal effect of the non-civilian good on the civilian good is restricted in order to maintain the same level of social utility as follows:

(5) $$\frac{d\dot{Q}_C}{d\dot{Q}_M} = \frac{\eta(\gamma_2 - \gamma_1)}{\theta} < 0 .$$

Therefore, if the marginal effect of non-civilian good on the civilian good is less than $\frac{\eta(\gamma_2 - \gamma_1)}{\theta}$, social utility will decrease with increased production of the non-civilian good because the utility loss from decreasing the production of the civilian good is greater than the utility gain from increasing the production of the non-civilian good. This effect can be shown as follows:

(6) $$\frac{du}{dQ_M} = \eta(\gamma_1 - \gamma_2) + \frac{dQ_C}{dQ_M} \cdot \theta .$$

If $\frac{dQ_C}{dQ_M} < \frac{\eta(\gamma_2 - \gamma_1)}{\theta}$, then $\frac{du}{dQ_M} < 0$.

Also, we can recognize in equation (4) that if the North Korean people have a stronger preference for a civilian good (i.e., food) than for a non-civilian good (thus bigger θ and smaller η), the marginal effect of the non-civilian good on social utility will be small. Otherwise, if the North Korean people have a stronger preference for national security than for goods produced for civilian consumption (smaller θ and bigger η), the marginal effect of the non-civilian good on social utility will be large. It implies to what extent military oriented policy is actually dependent upon where the North Korean people place their preference, either on non-civilian or civilian goods, because the overriding factor determining

resource allocation (either between the military or the civilian populace) is the preference disposition of the North Korean people.

Pro-military Oriented Policy and Food Production

As previously discussed, an economic policy that is pro-military will cause agricultural production to decrease because pro-military policy allocates fewer resources to the civilian sector so that those resources that will be made available to the agricultural sector will decrease. As seen in Figure 3, a decrease of input factors, X, from X^1 to X^2 decreases food production, Q_F, from Q_F^1 to Q_F^2. One thing that should be noticed is that there could possibly be another factor that contributes to a decrease food production even greater in magnitude than just from Q_F^2 to $Q_F^{2'}$. That is a decrease in factor productivity in the food production function which causes reduction of food production given X^2 so that Q_F^2 decreases to $Q_F^{2'}$. This decrease in factor productivity is due to inefficient management stemming from the adoption of militaristically oriented policy stance. Food production should therefore be identified in terms of not only its input-out relation but also in ill effects that come about as the result of inefficient management practices.

[Place Figure 3 Approximately Here]

To identify the impacts that both input factors and inefficient management have on food production, this study developed an econometric model as follows:

(6) $$Q_F = \alpha_0 + \alpha_1 X + \alpha_2 D + \alpha_3 W + e,$$

where Q_F is agricultural output, $X = \dfrac{\sum_i^n x_1^i + \sum_i^n x_2^i + \cdots + \sum_i^n x_k^i}{N \cdot K}$ is an input factor index, D is a military oriented policy dummy variable, and W is a weather dummy variable. The variable, e, is a random disturbance term which will absorb the effects of any other omitted variables that are germane to food production. In the model, α_1 will show how a decrease in input factors influences agricultural production. The parameter α_1 is expected to be positive in the model because of its input-output

relationship. α_2 will show how military oriented policy influences agricultural production. α_2 is expected to be negative because pro-military oriented policy reduces efficiency of agricultural management so that the agricultural production function will shift down.

Data

This study uses time series data from 1961 to 2007 for food production and input factors. All time series data are obtained from the United Nations Food and Agriculture Organization's (FAO) database. The recent data that are missing in the obtained FAO dataset are obtained from Korean government sources including the Bank of Korea, Ministry of Unification, and Korean Rural Economy Institute. For food production, this study uses rice and maize data. According to the rationing system now in place in North Korea, the North Korean government provides 75 percent of daily calorie intake with rice and maize. Of this daily caloric intake, 70% of the cereal ration is obtained from rice and 30% from maize.

To construct an input factor index, this study utilizes agricultural labor, arable land, mechanization, and fertilizer data. The input factor index is obtained through two stages of normalization. Initially, each individual data observation is normalized by using that data's average value during the sample period of time (N = 47 in this study). Then, the sum of the normalized values for each data grouping is divided by the total number of input factors (K = 4 in this study). The index represents the degree of resource availability for agricultural production. Since the mid-1990s the North Korean government has publicly promoted a pro-military oriented policy. Therefore, this study uses a policy dummy variable in order to quantify the relationship between pro-military oriented policy and food production during this sample period of time. As reported by the World Food Program (WFP), North Korean agriculture has been negatively impacted by natural disasters like floods and/or blight during the sample period of time. In order to quantify weather's impact on food production, this study includes a weather dummy variable in the econometric model.

Another purpose of this study is to anticipate the *ex ante* food balance subject to North Korean governmental policy which influences resource availability for agricultural production and the efficiency

of agricultural management. Food balance is defined as Q_F^S / Q_F^D, where Q_F^S is food supply and Q_F^D is food demand. Q_F^D is determined by government rationing and population level. The rationing standards on occupation and age are used for simulation. This study uses the average increasing rate of population during the sample period of time for simulation. This study simulates two different policy scenarios using the parameters estimated from the econometric model. At first, this study simulates *ex ante* food balance to identify the impact of resource availability on food balance given the current pro-military oriented policy stance of the North Korean government. In doing this, this study uses the average increasing rate of population during the sample period of time as a reference point for increasing rates of input factors. Next, this study simulates *ex ante* food balance to identify the impact of pro-military oriented policy on food balance given a particular level of input factors. In doing this, this study incrementally reduces the value of *D* from one to zero.

Empirical Results

In order to track North Korean food production in terms of resource availability, policy priority, and natural disaster, this study uses equation (6). For estimation, the input factor index will better represent the resource's impact on food production than that of just a single input factor. Using a double log model, this study estimates the unknown parameters of resource variable and policy and weather dummy variables and is expressed as follows:

$$\begin{array}{lllll} lnQ_F = 0.09586 + 0.84769\ lnX - 0.34335\ D - 0.09346\ W & & & & \\ t\text{-}ratio: & (3.64) & (10.05) & (-7.24) & (-1.80) \\ Adj\text{-}R^2: & 0.7686 & & & \end{array}$$

The coefficient of determination shows that the model explains fairly well variations in food production. The *t*-ratios would reject Type I error and conclude that all three explanatory variables influence food production. Furthermore, the three explanatory variables have signs that are consistent with our expectations.

$\hat{\alpha}_1$ shows an almost 1:1 positive relationship between food production and agricultural resource allocation. Since the mid-1990s, agricultural resources, including fertilizer, chemicals, mechanization, and

agricultural labor, available for agricultural production have remarkably decreased. For example, agricultural fertilizer consumption decreased from 832 thousand tons in 1990 to 93 thousand tons in 1996. The number of farm tractors decreased from 700 thousand in 1990 to 642 thousand in 1996. Also, shortages in fuel have also reduced the operating rate of farm machinery. Although total population increased during the sample period of time, the number of agricultural laborers has decreased since the mid-1990s, possibly as a result of North Korea's pro-military policy stance in diverting manpower from the farm to the military. These decreases in agricultural input factor availability since the mid-1990s have negatively influenced North Korean food production. According to the econometric model's estimates, a 10% decrease in input factors decreases food production by 8.5%.

Although the impact of the policy variable on food production is relatively small compared to that of input factor variable, $\hat{\alpha}_2$ shows that the impact of pro-military policy on food production cannot be ignored. As Kim (2001) indicated, if the North Korea can be emancipated from its pro-military oriented policy and those resources that had been tied up in the non-civilian sector were shifted over to the civilian sector, then additional manpower, billions of military dollars, and all other resources will be released for economic reconstruction. However, successful economic transformation from a pro-military policy to a more market oriented economic policy is the outcome of an evolutionary process because societies involve complex phenomena which cannot be deliberately manipulated (Hayek 1964). In the next section, this study simulates the impacts on food production that stem from a gradual shifting away from the current militaristic policy to that of the free market in North Korea.

Finally, as expected, poor weather decreases food production. However, the estimated value is relatively small compared to those of input factor and policy variables. It implies that the food deterioration that has been occurring in North Korea since the mid-1990s is due more to resource limitations and inefficient management than poor weather. According to our results, poor weather reduces food production by 432 thousand tons.

Food Demand in North Korea

All grain harvested is procured and distributed by the government. Once procured, the North Korean government then rations both rice and maize to its citizenry according to a basic formula which varies by location and the recipient's age and occupation. All households are registered at an agricultural cooperative, village or town, by family status and composition (newly born, infants, nursery/school age children, adults by work grade, heavy/light, or pensioners). Each person is registered at either an agricultural cooperative or the nearest Public Distribution System of Food (PDSF) center by a category of entitlement that is based upon the individual's age and occupation. All key commodities - foremost rice and maize, but also meat, fish or vegetables - are channeled through these centers and distributed to the non-agricultural population, usually twice a month, according to a ration scale that is centrally determined, keeping all rationing quantities in line with a commodity's overall availability is at a given time. Table 2 shows the daily per capita ration amounts for both rice and maize in North Korea.

[Place Table 2 Approximately Here]

Based on this ration schedule, this study calculates *ex post* food balances in North Korea. As shown in Table 3, food balances have changed from surplus to deficiency since 1995. As a result, we can expect that actual food consumption has decreased since 1995.

[Place Table 3 Approximately Here]

Simulation

In order to identify how many agricultural input factors should be increased to meet food demand given the current policy, this study simulates *ex ante* food balance using estimated parameters in the previous section. In the simulation, this study assumes that the North Korean total population increases by 4.5% each year, which happens to be the average increasing rate for the study's time period of1961 to 2007. Due to the lack of data, this study uses percentage shares for three age groups in 2005 as references so as to calculate the population for each age group for the simulated years. As seen in Table 2, the government ration is classified into detailed classes depending upon age and occupation. However, this study simplifies ration classifications into three groups using the ages and average ration amount for each of

three groups to simulate *ex ante* food balance due to the limitations in data availability. *Ex ante* food balance is simulated by increasing agricultural input factors given the current pro military oriented economic policy. The increasing rates of agricultural input factors are increased proportionally with an increasing population rate.

Table 4 shows the results of the scenario. The *1*'s (ones) in the second column represent government food ration plan in each year, while each number in columns three to eight represents food production given a particular level of agricultural resource availability and policy. Therefore, if a number in columns three to eight is less than one (< 1), food deficiency is indicated. If a number in columns three to eight is greater than one (> 1), this then indicates a food surplus. For example, the value 0.69353 in the third column and the fourth row represents food deficiency at around the 30% level for 2011. Another example, 1.15917 in the fifth column and the last row represents a food surplus of around 16% for 2025.

As Table 4 shows, in order to meet food demand given North Korea's current military oriented policy, agricultural input factors should be increased more than two fold the rate of increase in the North Korean population. For example, under population increase factors of 1 and 1.5 and with the current military oriented policy, food production appears less than the food ration in every year of simulation, while food production appears more than the food ration from 2020 under a 2 fold population increase. The greater the increase in agricultural input factors made available, the faster food balance improves. Food balance appears to have a surplus from 2016 under a 2.5 population increase factor and from 2014 with a population increase factor of Pop × 3.0. According to the results, the food balance is deteriorated even though agricultural input factor increases at the same rate as the rate increases for the population. This implies that agricultural input factors should be increased at a rate more than that of the increasing rate in population growth in order to ensure that the food balance for the average North Korean is not imperiled given military oriented policy.

[Place Table 4 Approximately Here]

This study simulates *ex ante* food balance under a pro-market oriented policy approach with the same increasing rates of agricultural input factors as considered in the first scenario. The results show that

food balance appears to be more quickly recovered under pro-market oriented policy compared to pro-military oriented policy. Given a pro-market oriented policy, food balance appears greater than food demand from 2011 in all cases except for a population increase factor of 1. This result implies that although pro-market oriented policy improves food production, agricultural resources should be increased more than that of population to meet food demand. It is not ambiguous that food balance should be recovered more quickly and more enough with pro-market oriented economic policy than with pro-military oriented policy.

[Place Table 5 Approximately Here]

Finally, since a 'big bang' policy transformation is difficult as has been shown in previous studies (Terry, 1988; Lau, Qian, and Roland, 1997 and 2000), this study examines the sorts of interactions that occur in a mixed policy environment such as that is observed in Chinese agriculture.[4] In order to do this, this study simulates *ex ante* food balance by gradually transferring economic policy from a pro-military stance to that of a more pro-market oriented policy approach given Pop×2.0. This study reduces the value of the *D* variable by 10% to gradually transfer pro-military oriented policy towards that of a more pro-market oriented policy. Therefore, if the value of *D* is less than one and greater than zero, it represents a mixed economic policy. Lesser values for *D* variable represent a more market oriented policy approach.

Table 6 shows the results of the scenario. Shifting from pro-military economic policy towards a pro-market economic policy, food balance appears to improve better in terms of quantity and time as compared to the pro military economic scenario. For example, a surplus in the food balance appears from 2020 under pro-military oriented policy while a surplus food balance appears from 2014 when the pro-military oriented economic policy is alleviated by 50%. Also, the food balance is improved whenever the pro-military oriented policy is mitigated. For example, the food balance is 0.91661 under $D = 0.5$ in 2011 while the food balance is 0.77201 given $D = 1$ in 2011.

[Place Table 6 Approximately Here]

Conclusion

Since North Korea's inception, the leaders of North Korea have pursued an economic policy that is opposed to integration into the larger global economy. . In doing so, North Korea has minimized trade with the world economy. Furthermore, North Korea has strictly adhered to a largely militaristically centered economic policy with overall concerns centered on national security since the collapse of the former Soviet Unions and the death of the founder of North Korea. Such adherence to a relatively isolated and unbalanced policy resulted in tragic starvation in mid-1990s and remaining current economic hardship in North Korea. However, there has not been a comprehensive economic study that has primarily focused on North Korean agriculture from a neo-classical economic viewpoint. Taking this into consideration, this study analyzes North Korean food supply and demand based upon neo-classical economic theory.

In so doing, this study described the relationship between pro-military oriented policy and deficiency of food balance using modified neo-endowment economic theory. Government control of resources results in decreasing social utility by distorting national production toward the government preference rather than individual consumer's. In this study, we show that if marginal effect of non-civil good on civil good is greater than $\frac{\eta(\gamma_2 - \gamma_1)}{\theta}$, social utility will decrease with increases in the production of a non-civil good because the utility loss from decreasing civil good production is greater than the utility gain from increasing non-civil good production. This study also shows that if North Korean people have a stronger preference for civil goods like food than for non-civil good (bigger θ and smaller η), the marginal effect of the non-civil good on social utility will be small. Otherwise, if the North Korean people have a stronger preference for national security than for civil goods (smaller θ and bigger η), the marginal effect of the non-civil good on social utility will be large. It implies that to what extent of military oriented policy could be derived is dependent upon where the North Korean people place their preference (on either non-civil good or civil good) because the conflict between pro-military policy and social utility is ultimately resolved by the preference of the North Korean people.

Second, this study quantifies the impact of agricultural resource and policy on food production during the sample period of time. As expected, food production decreases along with a decrease in agricultural input factors and implementation of pro-military oriented policy. Also, it is shown that poor weather negatively influences food production.

Finally, this study simulates *ex ante* food balance. In order to meet food demand, agricultural input factors should be more quickly increased than that of increasing rate of population whether pro-market oriented policy implements or not. And if a pro-market oriented policy is implemented, food balance appears to recover more quickly from food deficiency to food surplus.

In this study, we face with many difficult cases. Most of them are related to lack of information about North Korean economy. However, this study developed an economic approach to quantitatively analyze the North Korean food demand and supply based on neo-classical economic theory. Faced with a lack of economic studies about North Korean agriculture, this effort will lead to further valuable studies which will help gain a better understanding of the North Korean food crisis. Our model serves as only a first step in trying to rigorously understand the state of North Korean food supply and demand. In the current vein of understanding, we think it is important to generate a class of models that lends insight and provides for a more critical understanding as to the impact the recent food crisis has had in and on the North Korean economy. In our study, the presence of search frictions plays that role.

Table 1. Percentage share of trade to GDP in 2003

North Korea	South Korea	Japan	China	U.S.
8.1	61.3	20.2	51.6	18.5

Sources: Congressional Research Service and International Monetary Fund

Table 2. Rice amd maize per capta daily rations, North Korea

Occupation and age group	Per capita daily ration (g)	Ratio of rice to maize	
		Pyongyang	Other
High-ranking govt officials	700	10:0	10:0
Regular laborers	600	6:4	3:7
Heavy labor workers	800	6:4	3:7
Office workers	600	6:4	3:7
Special security	800	7:3	7:3
Military	700	6:4	3:7
College students	600	6:4	3:7
High school students	500	6:4	3:7
Primary school students	400	6:4	3:7
Kindergarten	300	6:4	3:7
Children unde 3	100-200	6:4	3:7
Aged and disabled	300	6:4	3:7

Source: National Unification Board, Summary of North Korea, Seoul, 1997, p.359.

Table 3. North Korea's Food Balance

	1980	1990	1995	2000	2005	2006	2007
Production	5,346,400	5,800,000	3,382,000	2,731,000	4,212,000	4,229,000	3,937,000
Ration	3,718,585	4,345,000	4,684,524	4,930,862	5,075,386	5,097,604	5,118,312
Balance	1,627,815	1,455,000	-1,302,524	-2,199,862	-863,386	-868,604	-1,181,312

Unit: 1000kg

Table 4. Food balance given pro-military oriented policy ($D = 1$)

Year	Ration	*Pop×1.0*	*Pop×1.5*	*Pop×2.0*	*Pop×2.5*	*Pop×3.0*	*Pop×5.0*
2011	1	0.694	0.732	0.772	0.813	0.856	1.039
2012	1	0.689	0.740	0.795	0.852	0.912	1.181
2013	1	0.684	0.749	0.818	0.892	0.971	1.342
2014	1	0.680	0.758	0.842	0.935	1.035	1.525
2015	1	0.675	0.766	0.867	0.979	1.102	1.734
2016	1	0.671	0.775	0.893	1.025	1.174	1.970
2017	1	0.666	0.784	0.919	1.074	1.251	2.239
2018	1	0.662	0.793	0.946	1.125	1.333	2.545
2019	1	0.657	0.802	0.974	1.178	1.420	2.893
2020	1	0.653	0.811	1.003	1.234	1.513	3.288
2021	1	0.649	0.820	1.032	1.293	1.612	3.737
2022	1	0.644	0.830	1.062	1.354	1.717	4.247
2023	1	0.640	0.839	1.094	1.418	1.829	4.827
2024	1	0.636	0.849	1.126	1.486	1.949	5.486
2025	1	0.631	0.858	1.159	1.556	2.076	6.235

Pop×α represents that agricultural input factors increase by more α time than population increase rate.

Table 5. Food balance given pro-market oriented policy ($D = 0$)

Year	Ration	*Pop×1.0*	*Pop×1.5*	*Pop×2.0*	*Pop×2.5*	*Pop×3.0*	*Pop×5.0*
2011	1	0.978	1.032	1.088	1.146	1.206	1.464
2012	1	0.971	1.044	1.120	1.201	1.285	1.664
2013	1	0.965	1.056	1.153	1.258	1.369	1.892
2014	1	0.958	1.068	1.187	1.317	1.459	2.150
2015	1	0.952	1.080	1.222	1.380	1.554	2.444
2016	1	0.945	1.092	1.258	1.445	1.655	2.777
2017	1	0.939	1.105	1.295	1.514	1.764	3.157
2018	1	0.933	1.117	1.334	1.586	1.879	3.588
2019	1	0.927	1.130	1.373	1.661	2.002	4.078
2020	1	0.920	1.143	1.413	1.740	2.133	4.635
2021	1	0.914	1.156	1.455	1.822	2.272	5.267
2022	1	0.908	1.169	1.498	1.909	2.421	5.987
2023	1	0.902	1.183	1.542	1.999	2.579	6.804
2024	1	0.896	1.196	1.587	2.094	2.747	7.733
2025	1	0.890	1.210	1.634	2.193	2.927	8.789

Table 6. Food balance and gradual policy transformation under *Pop×2*

Year	Ration	*D*=1	*D*=0.9	*D*=0.8	*D*=0.7	*D*=0.6	*D*=0.5	*D*=0.4	*D*=0.3	*D*=0.2	*D*=0.1	*D*=0
2011	1	0.772	0.799	0.827	0.856	0.886	0.917	0.949	0.982	1.016	1.052	1.088
2012	1	0.795	0.823	0.851	0.881	0.912	0.944	0.977	1.011	1.046	1.083	1.120
2013	1	0.818	0.847	0.876	0.907	0.939	0.971	1.005	1.041	1.077	1.114	1.153
2014	1	0.842	0.872	0.902	0.934	0.966	1.000	1.035	1.071	1.109	1.147	1.187
2015	1	0.867	0.897	0.929	0.961	0.995	1.029	1.065	1.103	1.141	1.181	1.222
2016	1	0.893	0.924	0.956	0.989	1.024	1.060	1.097	1.135	1.172	1.216	1.258
2017	1	0.919	0.951	0.984	1.019	1.054	1.091	1.129	1.169	1.209	1.252	1.295
2018	1	0.946	0.979	1.013	1.049	1.085	1.123	1.162	1.203	1.245	1.289	1.334
2019	1	0.974	1.008	1.043	1.080	1.117	1.156	1.197	1.238	1.282	1.327	1.373
2020	1	1.003	1.038	1.074	1.111	1.150	1.190	1.232	1.275	1.320	1.366	1.413
2021	1	1.032	1.068	1.105	1.144	1.184	1.225	1.268	1.313	1.358	1.406	1.455
2022	1	1.062	1.100	1.138	1.178	1.219	1.261	1.306	1.351	1.398	1.447	1.498
2023	1	1.094	1.132	1.172	1.212	1.255	1.299	1.344	1.391	1.440	1.898	1.542
2024	1	1.126	1.165	1.206	1.248	1.292	1.337	1.384	1.432	1.482	1.534	1.587
2025	1	1.159	1.200	1.242	1.285	1.330	1.376	1.424	1.474	1.526	1.579	1.634

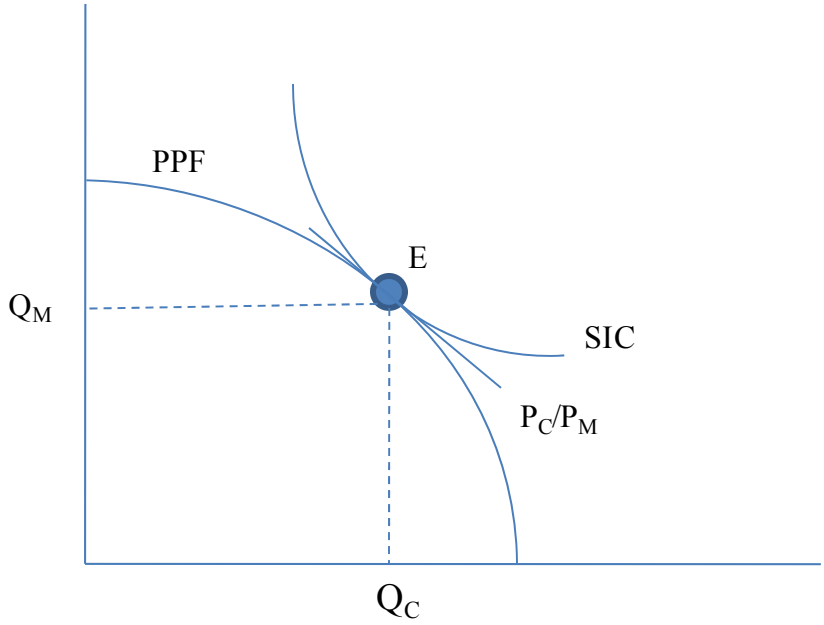

Figure 1. Autarky in the North Korean Economy

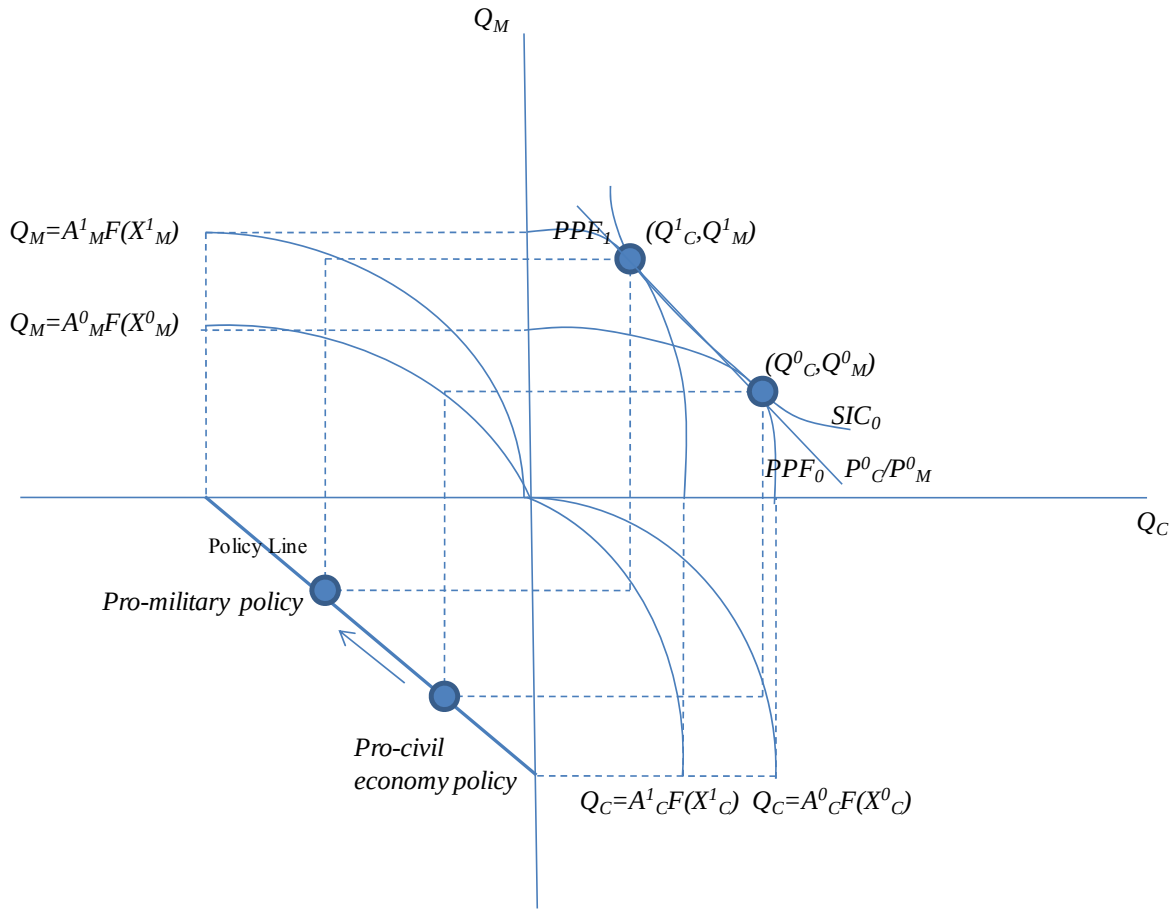

Figure 2. Impact of pro-military oriented economic policy on the economy

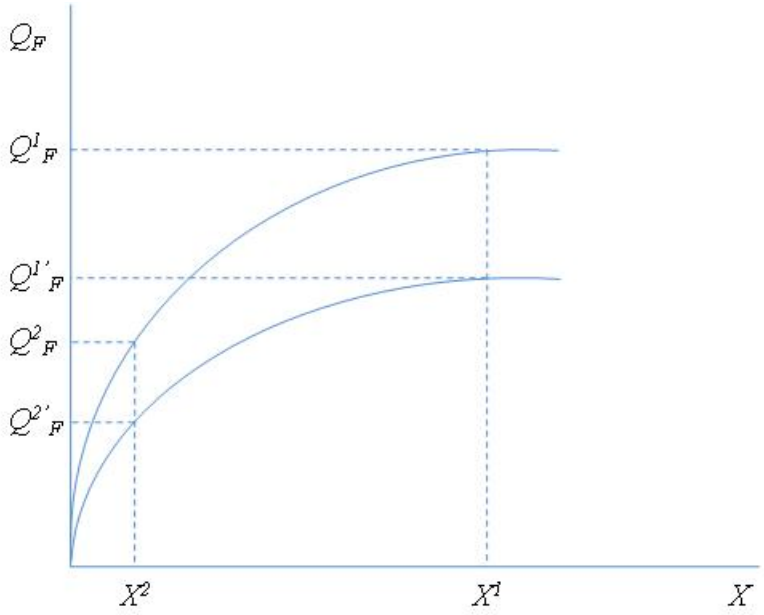

Figure 3. Pro-military oriented policy and food production

Footnote 1.
According to the book published by KDI, the independent national economy implies that the country produce and consume all what the people of the country need without depending on foreign country. Since establishment of socialist government in 1948, North Korea has maintained this stratagem up to now.

Footnote 2.
The opportunity cost of non-civil good in terms of civil good also represents the marginal rate of transformation (MRT) of non-civil good for civil good, defined as the amount of civil good the economy is willing to trade in exchange for an amount of non-civil good.

Footnote 3.
According to the North Korean price regulation ratified in 1996, prices of goods and services are determined by government based on demand and supply expected by government. Therefore, the relative prices are independent of change in demand and supply.

Footnote 4.
Reform of policies governing agriculture in China began in 1977. The state maintained the existing design of state planning for major agricultural products but adjusted state-planned quotas and prices, permitted markets to revive (Terry Sicular, 1988).

References

Choi, E.K., M. Yesook, and Ŭ.H. Kim (2003). North Korea in the World Economy. Routledge Advances in Korean Studies; 4.

Hayek, F.A. (1945). The Use of Knowledge in Society. *The American Economic Review* 15(4): 519-530.

Lau, L.J., Y. Qian, and G. Roland (1997). Pareto-improving economic reforms through dual-track liberalization. *Economics Letters* 55; 285-292.

Lau, L.J., Y. Qian, and G. Roland (2000). Reform without Losers: An Interpretation of China's Dual-Track Approach to Transition. *Journal of Political Economy* 108(1): 120-143.

Montinola G., Y. Qian, and B.R. Weingast (1996). Federalism, Chinese Style: The Political Basis for Economic Success. *World Politics* 48.1: 50-81.

Nanto, D.K., and E. Chanlett-Very (2009). North Korea: Economic Leverage and Policy Analysis. Congressional Research Service, CRS Report for Congress, 7-5700.

Noland, M., and S. Robinson (2000). Modeling Korean Unification. *Journal of Comparative Economics* 28: 400-421.

Roland, G., and T. Verdier (1999). Transition and the output fall. *Economics of Transition* 7(1): 1-28.

Sicular, T. (1988). Plan and Market in China's Agricultural Commerce. *Journal of Political Economy* 96(2): 283-307.