Development Studies Series 02

Local Nutritional Availability and Adult Height: Evidence from South Korea, 1946-1977

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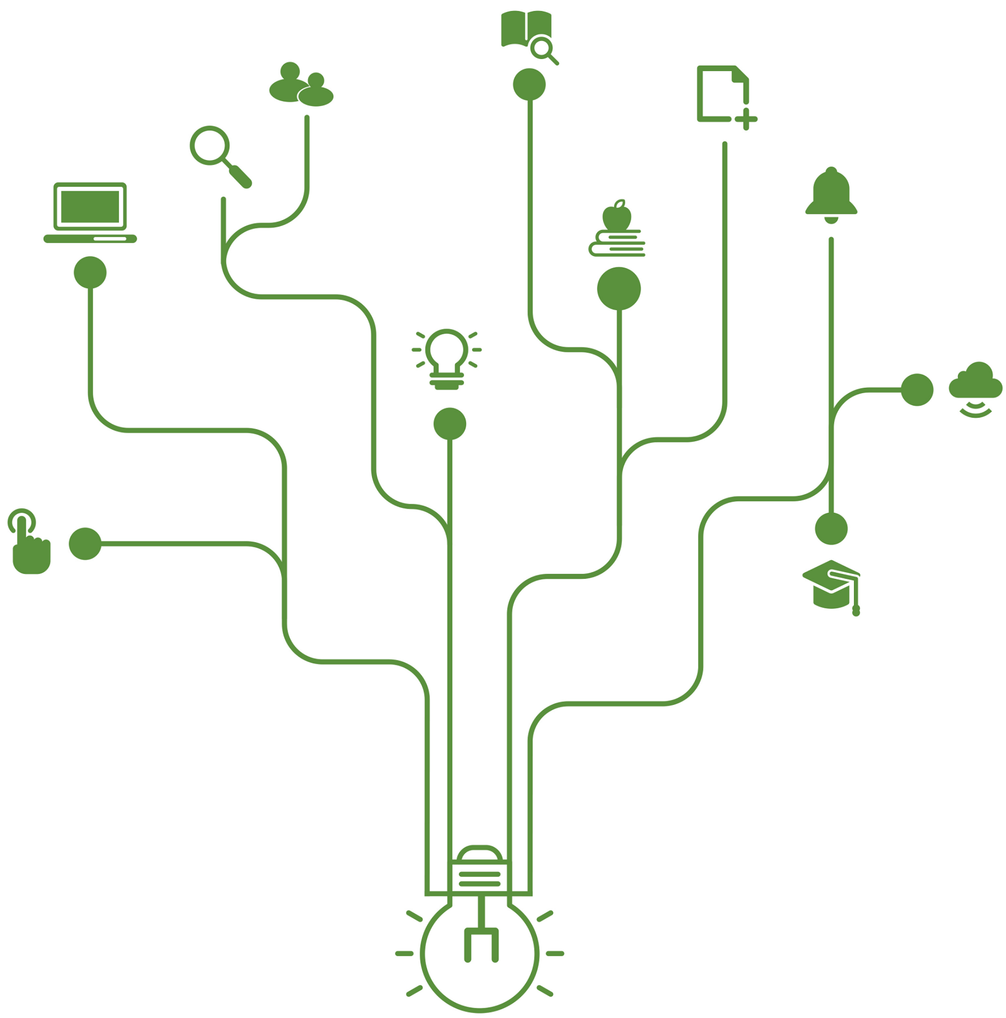

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KDI School of Public Policy and Management

Local Nutritional Availability and Adult Height: Evidence from South Korea, 1946-1977

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Abstract

It is generally accepted that the rapid economic growth in South Korea during the second half of the twentieth century greatly improved the standards of living of the country's population. However, it is not fully understood how the living conditions in South Korea changed over time, and what are the major factors that produced the changes. For instance, there is still much to be learned about how the process of improvements differed by socioeconomic characteristics, and about how the experiences of each birth cohort differed with each other. We do not fully understand how particular economic or social changes affected the wellbeing of the population, either. Rigorous research on these issues is often seriously hampered by shortage of appropriate data, especially for the periods prior to the 1970.

In our previous study (Lee 2016), supported by the 2015 Cliometric Study Program of the KDI School of Public Policy and Management, we investigated how biological indices of standards of living, such as height, weight, and body-mass-index (BMI, hereafter) changed across birth cohorts born between 1946 and 1957, based on a newly collected sample of military records for more than 18,000 conscripts. We found that the mean height at conscription slightly declined from the 1946 cohort to the1951 birth cohorts before it rapidly increased across cohorts. The mean height increased by more than two centimeters in just 6 years between 1951 and 1957. We also found considerably large variations across provinces in the patterns of changes in anthropometric measures as well as the levels of the measures. In the previous study, however, we were unable to determine what factors produced

the changes in anthropometric measures across different birth cohorts and across different regions.

In the present study, we investigated how nutritional availability in two crucial periods for human growth, namely, early childhood (from conception to age 2) and adolescence (from age 12 to age 16), affected the heights of Korean conscripts born from 1946 to 1957. For the purpose, we constructed province- and county-level data on agricultural productions, and matched the dataset with the sample of conscripts using the information on place of residence. We also explored how much improved nutrition during infancy and adolescence contributed to the increase in heights between the 1951 cohort and the 1957 cohort.

We used the amounts of calories and three major nutrients (protein, fat, and carbohydrate) per farm household adult equivalent in a given province or county as our primary measures of local nutritional availability. In addition to nutrition variables, we considered local environmental conditions indicated by population density and nonfarm population share as well as personal and family characteristics such as season of birth, family size, and father's occupation. We selected several different samples for whom the effects of our measure local nutritional availability on heights might differ with one another. These samples include: men from counties with information on nutritional availability, men from rural counties (baseline sample), and farmers' sons living in rural counties.

The regression results suggest that variables on local nutritional availability are generally positive and statistically significant. According to the results from the rural county sample, a person who spent infancy in a province that produced calories per farm population one standard deviation above the mean would have been about 0.2 centimeters taller at the time of conscription, if other things equal. A one standard deviation increase in protein or carbohydrate in infancy would result in an increase in height by a similar magnitude. The estimated coefficients for nutritional availability variables in adolescence are generally smaller in magnitude and statistically less significant.

A major drawback of our analyses is that the true birth place of a conscript is unknown. To reduce potential measurement errors arising from geographic mobility between birth and conscription, we used a subsample of men from rural counties whose province of residence at the time of conscription is the same as the province of "original family place (Bonjeok)." If a conscript's current address and Bonjeok are identical, it is likely that he was born in the current province of residence. About 79 percent of the full sample and 91 percent of the rural county sample reported the same current and Bonjeok province, which implies that prior geographic mobility of the conscripts in the sample was probably low. The regressions conducted based on the subsample reveal larger effects of nutritional availability on heights, compared to the baseline results.

We performed height regressions with various samples alternative specifications. Adding the conscripts' own education does not noticeably change the results. By contrast, inclusion of province fixed effect greatly increases the size of the effects of nutritional availability in early childhood. The effects of nutrition availability variables in adolescence are stronger for the 1946–1950 birth cohorts than those for the 1951–1957 birth cohorts. If the sample is limited to farmers' sons from rural areas, the estimated coefficients for nutrition variables become larger. If the sample is extended to include men from urban counties with minimum agricultural productions, the baseline results remain little changed.

We finally explored how much improved nutrition contributed to the increase in height between the 1951 and 1957 birth cohorts. The cohort trends of nutritional availability and height match well, which is consistent with the hypothesis that early-life nutrition mattered for growth of stature for the birth cohorts under investigation. For estimating the contribution of improved nutrition to the increase in height, we computed the change in height predicted by change in nutrition using height regression results and estimated change in each nutritional availability variable between 1951 and 1957. The result suggests that improved nutrition in early childhood and adolescence accounts for 30 percent to 50 percent of the increase in adult height that was gained from the 1951 and 1957 birth cohorts. Increased nutritional availability during early childhood explains a lion's share of the contribution.

The results of this study strongly suggest that nutrition was an important determining factor of biological standards of living indicated by adult height. In particular, provisions of calories and protein were strongly associated with larger stature. Food availability during early childhood was more critical for human growth than nutrition in adolescence. This result is consistent with the consensus that catch-up growth in adolescence is insufficient to fully make up for deficiencies in early childhood. Although our estimate is highly preliminary

and subject to errors, it is likely that improvements in the quantity and quality of nutritional intakes that were made possible by increased incomes and enhanced agricultural productivity significantly contributed to the rise of biological standard of living indicated by changes in anthropometric measures.

Keywords:

Introduction

South Korea has achieved a rapid economic growth since the liberation from the Japanese occupation in 1945. Within only four decades after the country was recovered from the devastation of the Korean War (1950-1953), it emerged as one of the richest newly industrialized nations. Previous estimates of incomes suggest that the real GDP per capita stagnated by the early of 1960s, and then started to rise rapidly in the following years (Pyo 2001; Kim 2012; Cha 2014). According to World Bank Statistics, the annual growth rate for per capita GNP in Korea was 6.6 percent for the period between 1965 to 1999, the highest among all countries in the world (Song 2003).

It is generally accepted that the rapid economic growth in South Korea during the second half of the twentieth century greatly improved the standards of living of the country’s population. Koreans today enjoy much higher levels of material wellbeing compared to those who lived in the country six or seven decades ago. Per capita income in dollar value today is more than 400 times greater than that in 1953. Life expectancy at birth today is 30 years longer than it was in 1960.

It is less clear when Koreans’ standards of living began to take off. Available evidence pertaining to several measures of human wellbeing suggest that improvements were well underway by the 1960s. Although vital statistics prior to 1970 are not highly reliable, it appears that the life expectancy substantially rose between 1960 and 1970 (National Statistical Office 1998). There were substantial fluctuations in the rates of morbidity and mortality caused by acute infectious disease from 1946 to 1954, but a long-term declining trend emerges had there not been for the short-term fall and rise in 1948 and an increase in 1951 (Lee 2016, Figure 2-12). Age at menarche is often used as an index of biological standard of living. Several studies found that menarcheal age of girls, an index of biological standard of living, declined especially after 1946 (Hong et al., 1993; Hwang et al., 2003; Sohn, 2016).

Even with this general consensus on the long-term trend in the standards of living, however, it is not fully understood how the living conditions in South Korea changed over time, and what are the major factors that produced the changes. For instance, there is still much to be learned about how the process of improvements differed by socioeconomic characteristics, and about how the experiences of each birth cohort differed with each other. We do not fully understand how particular economic or social changes affected the wellbeing of the population, either.

Rigorous research on these issues is often seriously hampered by shortage of appropriate data, especially for the periods prior to the 1970. We can obtain reasonably large and representative micro data on household incomes and consumption expenditures only for the period after the 1970s. Many of the previous studies that utilized biological measures of standards of living were based on recent survey data including aging birth cohorts, which are subject to some shortcomings such as selective survival of healthier individuals and shrinkage of heights at older age. Other studies of its kind relied on relatively smaller samples of particular demographic groups in the past, which makes it difficult to generalize the results for the entire population. Furthermore, the vast majority of the sources used by these studies do not allow us to infer socioeconomic backgrounds and ecological environments of individuals in growing ages.

In a previous study, supported by the 2015 Cliometric Study Program of the KDI School of Public Policy and Management, we attempted to overcome these limitations of currently available data on standards of living in South Korea prior to the 1970s by analyzing new data on Korean military records that were collected from the Military Manpower Administration. Using the new data, we investigated how biological indices of standards of living, such as height, weight, and body-mass-index (BMI, hereafter) changed across birth cohorts born between 1946 and 1957. In addition, we examined how the overall levels and changes across cohorts in the measures of wellbeing differed by province of residence.

We found that the mean height at conscription slightly declined from 165.8 centimeters for the 1946 cohort to 165.5 for the 1950 and 1951 birth cohorts. Afterwards, Korean men became taller at a considerably rapid pace. The mean height increased by more than two centimeters in just 6 years between 1951 and 1957. No secular changes in weights were observed for cohorts born from 1946 to 1951. Instead, we found a sharp decline and a recovery of weights around the first two years of the Korean War (1950 and 1951), which is probably attributable to the adverse effects of in-utero exposure to the Korean War (Lee 2014, 2017). We also found considerably large variations across provinces in the patterns of changes in anthropometric measures as well as the levels of the measures. The results of regression analyses show that the observed provincial differences in anthropometric measures do not disappear even if father's occupation and own education are controlled.

In the previous study, we were unable to determine what factors produced the changes in anthropometric measures across different birth cohorts and across different regions. Given that the differences across cohorts and regions remained if personal characteristics (father's occupation and own education) were taken into account, environmental factors, such as changes in nutrition and ecological conditions could play important roles. These remaining questions motivated additional collections of data that can provide information on local nutritional availability and ecological environment that were utilized for the current study.

In this study, we investigate how nutritional availability in two crucial periods for human growth, namely, early childhood (from conception to age 2) and adolescence (from age 12 to age 16), affected the heights of Korean conscripts born from 1946 to 1957. For the purpose, province- and county-level data on local nutritional availability were constructed and matched with the sample of conscripts using the information on place of residence. We also explore how much the observed increase in adult heights across birth cohorts can be accounted for by improved nutrition during infancy and adolescence.

We focus on height in this study for the following reasons. First, height is a primary index of cumulative net nutritional status during growing ages. Adult height is also known as a strong predictor of health and mortality. Therefore, establishing primary determinants of adult height will help to understand how and why standards of living in Korea changed over time. Second, our previous study revealed that the mean adult height slightly declined for the cohorts born prior to 1951, and then rapidly increased between the 1951 to 1957 birth cohorts. For these birth cohorts, no clear secular trends in weight were observed. In order to understand the causes of long-term changes in standards of living understanding, it would be more productive to pay attention to heights of which changes reveal secular trends for the cohorts under investigation.

A few studies provide evidence as to the long-term trends as well as socioeconomic differences in heights of Korean born prior to 1960. Some studies make comparisons across different birth cohorts (Hong et al. 1993; Hwang et al. 2003; Schwekendiek and

Jun 2010; Pak et al., 2011; Sohn, 2016), whereas other works largely concern with changes in age-specific anthropometric measures across different years (Lim et al., 1986; National Statistics Office, 1998; Pak, 2004; Lee and Park, 2005; Kim et al., 2006; Kim et al., 2008; Choi and Kim, 2012; Korean Agency for Technology and Standards, 2015). Compared to relatively active research on height changes during the Japanese colonial era (Choi and Schwekendiek 2009; Kim and Park 201), the trends and determinants of heights of individuals born between 1945 and 1960 are less clearly understood.

The studies on cohort-specific stature generally show that the heights of Korean people increased from the cohorts born after 1945, with substantial differences across birth cohorts and across demographic characteristics observed. Hwang et al. (2003) found that height increase was slower for the 1940-1959 birth cohorts and the 1960-1969 birth cohorts, based on a small sample of females included in the Ansan Health Study. Sohn (2016) also maintained that the trend of male heights was rather flat for the cohorts who experienced the Korean War and its aftermath in childhood. Hong et al. (1993) suggested that the population size of the place of residence was positively related to the heights of girls of menarcheal age.

Differences in height growth by gender and age group have been found by the studies based age- and year-specific measures. For the period between 1965 and 1975, the biggest height change was found at age 7 for both boys and girls (Kim et al. 2008; Choi and Kim 2012). Increase in average height of infants and younger children occurred more visibly during the period 1966-1984, which experienced a very rapid economic development in Korea (Kim et al. 2008; Choi and Kim 2012). Kim et al. (2008) reported that the heights in all age group between 12 and 24 stagnated between 1945 and 1950s, and then rapidly increased afterwards. Lee and Park (2005) found that the stature of children aged 6 to 11 stagnated or declined between 1953 and 1966.

This study is distinct from previous studies of Korean stature in several respects. First, this is the first attempt to investigate the determinants of adult stature based on a large and representative sample of the birth cohorts born between 1945 and 1960. The birth cohorts born shortly after the end of the Second World War spent their childhood and adolescence in the periods of upheavals including chaotic political and social circumstances that followed the liberation from the Japanese occupation, the Korean War that devastated the entire country, and the long and slow recovery from the war-caused destruction. By contrast, the birth cohorts born toward the end of the 1950s were the first generation to benefit from spending childhood in the periods of prolonged peace and rapid economic growth in the 1960s and 1970s. Thus, comparisons of these birth cohorts offer an opportunity to understand how the radical social and economic changes during the three decades after 1945 affected the standards of living of Korean people.

Second, the current study is the very first to explore how local nutritional availability and other family and environmental characteristics in growth periods affected adult heights in Korea. Previous studies of its kind were only able to consider differences in heights across birth cohorts and across regions (Choi and Schwekendiek 2009; Kim and Park 201). The present paper is one of very rare studies that examines the effects of parental characteristics, a key determining factor of living conditions in growth periods. It is difficult to find data that provide information on adult heights of individuals and their parental characteristics at the same time. In addition, we also created and utilized more detailed measures of local nutritional availability than those used in previous studies on nutrition and heights in the past (Haines et al. 2003). We used four different indices of nutritional availability including total calories and three major nutrients measured in two different crucial periods of human growth, infancy and adolescence. Improved quality of variables allows us to tackle several issues that have not been fully understood. For example, we can examine with our data which nutrient was more important for the growth of Koreans and how nutritional availability in infancy and adolescence affected adult heights differently.

This paper is organized as follows. We introduce two major datasets our analyses are based upon in Chapter 2, namely, a sample of Korean Military Records for more than 18,000 conscripts and province- and county-level data on agricultural productions from 1950 to 1980. In Chapter 3, we explain how we creased variables for local nutritional availability in early childhood and adolescence as well as other explanatory variables included in regression analyses for adult heights. We also explain in the chapter how we selected various samples used in our analyses. Chapter 4 provides the regression results presenting how nutritional availability in growth periods affected adult heights. We present the result of an exercise that show how much improved nutrition contributed to the increase in heights. The final chapter summarizes the results and their implications.

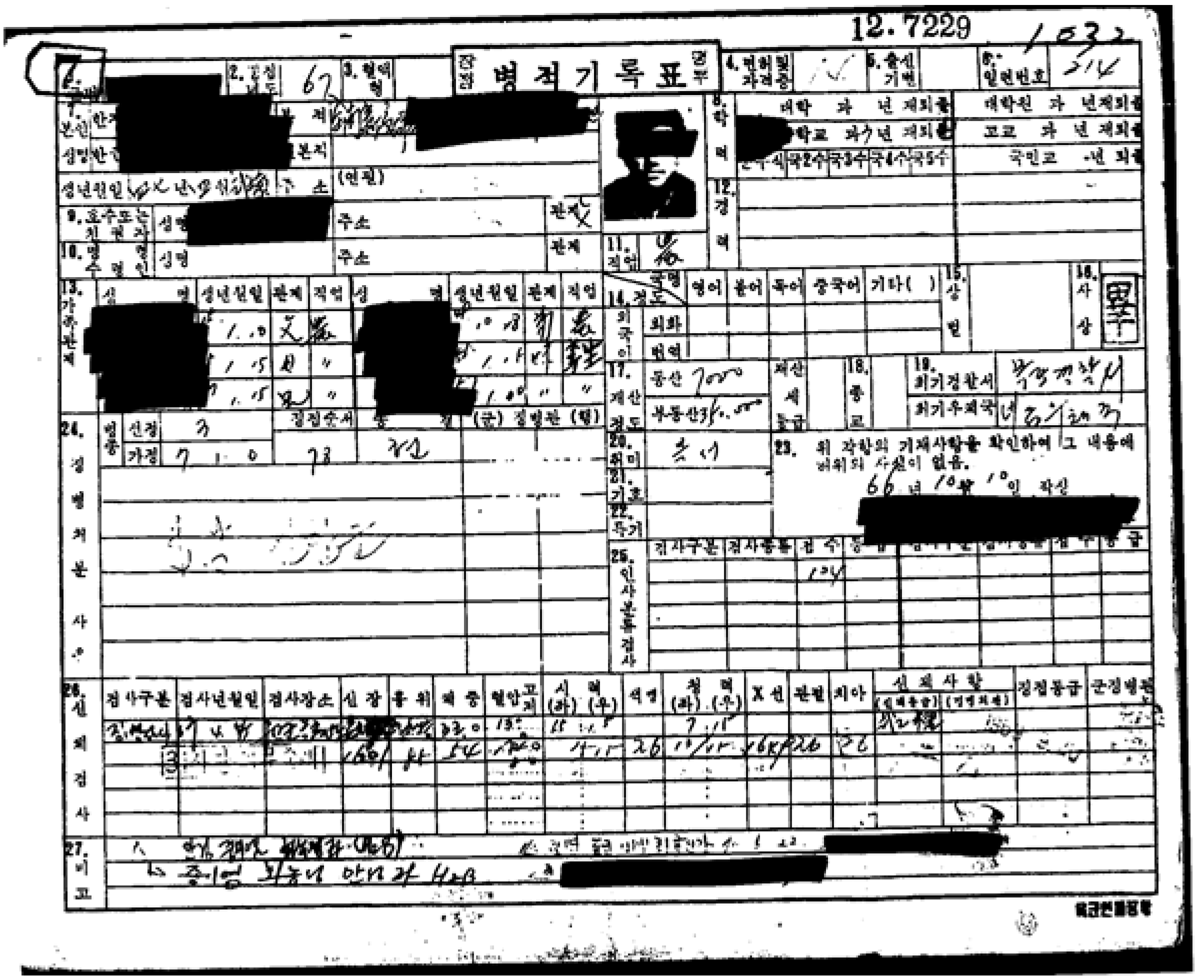
Data

Sample of Korean Military Records

The basic features and data construction methods are introduced in detail in a previous paper (Lee 2016), along with tables and figures providing descriptive statistics of primary variables on interest, including height, weight, and MBI. To make the current paper self-contained, we provide below a brief introduction of the sample of Korean Military Records.

After a large-scale recruitment was attempted on a compulsory basis following the outbreak of the Korean War, military service is a mandatory duty for all males in South Korea. All males have to take physical examinations for military conscription at age 20. Military record cards are produced for all males including those who are exempt from service. On the front page of the card, the information on personal and family characteristics as well as the results of physical examinations is recorded. For veterans, military service records are provided on the back page of the card.

The carded military records (CMR, hereafter) are kept in the central office of the Military Manpower Administration (MMA, hereafter). For the years from 2002 (for the birth cohorts born in 1982 or later), CMRs are available in machine-readable forms. For earlier birth cohorts, either image files or micro films of military records can be obtained. Judging from the total number of records, it appears that CMRs are available for the entire male population at least from the mid-1960s. Figure 2.1 shows a sample of CMR.



〈Figure 2.1〉 Sample of Carded Military Record

By obtaining permission from the MMA, we collected a 0.5% sample of CMRs for the birth cohorts born from 1946 to 1957. The CMRs for the individuals born from 1948 and 1957 are contained in the forms of image files that can be sorted according to the National Registration Number of which first six digits provides the birth dates. We selected men who were born in the 20th day of each month and whose ID ends with 4 or 6, which gave a one-in-150 sample. Further selections of records that are complete and readable provided us with a roughly 0.5% sample. For the birth cohorts born from 1946 to 1948, the CMRs are available in the forms of micro films. We selected the first 15 films from each roll composed of 3,000 films for these cohorts. If the selected film is incomplete or difficult to read, we replaced it by the next film.

To protect privacy of the individuals included in the sample, we deleted the following information from the selected CMRs: 1) the names of the conscript and family members, 2) military ID, 3) last seven digit numbers of National Registration Number, and 4) address below the level of county or district. The front and back pages of CMRs with the sensitive personal information deleted were scanned at the MMA, and we obtained the resulting image files. After duplicate records were detected and excluded, we inputted the information drawn from the image files into database.

We identified nine different types of CMRs in terms of format and content. Four major types, denoted as Form 1 to Form 4, account for the vast majority of the sample. The variables pertaining to the information on conscripts that available from all types of CMR include birth dates, place of current residence, place of original residence, education, occupation, specialty, results of physical examinations and aptitude tests, and conscription decision. The data also provide information on the age, occupation, relationship to the conscript of parents (or guardian) and other family members. The variables on physical examinations include height, weight, chest measurement, blood pressure, eyesight, and particular health problems.

〈Table 2.1〉 Number of Military Records by Year of Birth

Year of Birth	(A) Number of Records Collected	(B) Number of Incomplete Records	(C) Number of Duplicated Records	(D) Number of Records Inputted
1946	1,162	0	4	1,158
1947	1,036	0	5	1,031
1948	1,443	1	1	1,441
1949	1,143	0	23	1,120
1950	1,310	1	5	1,304
1951	1,303	0	43	1,260
1952	1,577	0	2	1,575
1953	1,404	11	35	1,358
1954	1,706	4	6	1,696
1955	1,875	0	52	1,823
1956	2,157	1	18	2,138
1957	2,243	3	29	2,211
Total	18,359	21	223	18,115

Source: Sample of Korean Military Records.

<Table 2.1> presents the number of samples by birth year. The total number of CMRs collected and scanned at the MMA is 18,359. Of these CMRs, we found 21 records with a missing page, and 233 duplicated records. After excluding these defected records, 18,115 CMRs were inputted into machine readable forms. The sample size for each birth cohort ranges from 1,031 (the 1947 birth cohort) to 2,211 (the 1957 birth cohort).

Data on County- and Province-Level Agricultural Productions

Official surveys or statistical reports on agricultural productions in South Korea began to be published since the early 1950s (Table 2.2). Prior to 1960, however, agricultural statistics compiled at county level only include the number of farm households, farm population, cultivated lands, and irrigation associations. Agricultural productions are provided at province level. Previous studies that utilized these data are mainly concerned with estimating nation-wide trends of agricultural productions (Hwang et al. 2014; Jeong et al. 2015; Jo 2007; Ko 2007). The only sources that report county-level agricultural outputs annually and in consistent manner is the statistical yearbooks published by each province (including two autonomous metropolitan cities at the time, Seoul and Busan) and each county. Accordingly, we constructed county-level agricultural production dataset largely from provincial or county statistical year books of various years, and supplemented it with province-level data drawn from other sources including Korea Statistical Yearbook, Food, Agriculture, Forestry and Fisheries Statistical Yearbook, and recent statistical reports published in some regions.

〈Table 2.2〉 Official Surveys or Statistical Reports on Farm Productions

Name	Publication Cycle	Start Year
Farm Household Economy Survey	Annual	1953
Food, Agriculture, Forestry and Fisheries Statistical Yearbook	Annual	1952
Agricultural Production Survey	Annual	1965
Survey of Production Index of Agriculture and Forestry	Annual	1965
Statistical yearbooks of each province or county	Annual	Generally in the middle of 1950s
Agriculture, Forestry and Fisheries Census	5 years	Agriculture survey started in 1960

The statistical yearbooks take bottom-up approach in the process of producing statistics. Each county compiles data reported from lower public administrative centers and publishes their own statistical yearbook annually. At the same time, related sections or bureaus of each province compiles data reported from the counties over which they have authority of control and publish provincial statistical yearbook annually, too. Finally, the National Bureau of Statistics collects all of these data and publishes the Korean Statistical Yearbook annually. The Food, Agriculture, Forestry and Fisheries Statistical Yearbook is also published via bottom-up approach. The Ministry of Agriculture publishes it annually after receiving data from local public offices under the jurisdiction of itself and conducting related researches and analysis on its own. Lastly, regional authorities occasionally collect and compile statistical yearbooks of the past and publish new statistical reports.

These records used for our data constructions available both on-line and in several public libraries. The on-line sources include the website of the National Archives of Korea (archives.go.kr), the National Assembly Library (nanet.go.kr), the Statistics Korea Library (lib1.kostat.go.kr), and several local governments. On these sites, many statistical books are deposited in the forms of pdf files or e-book files. Some of the records are available only from off-line sources. We collected the records that are not available on-line from the Statistics Korea Library, the Suwon Library of Seoul National University, the National Assembly Library and the National Archives of Korea, either through borrowing volumes or making copies under the permission of the library staffs. The list of the sources utilized for constructing our data on local agricultural productions is reported in Table 2.3.

〈Table 2.3〉 List of Data Sources Used in Construction of Dataset

Data Sources	Publication Year	Form
The Korea Statistical Yearbook	1952~1954 1957~1978	Pdf files
The Food, Agriculture, Forestry and Fisheries Statistical Yearbook	1955~1978	Pdf files
The Seoul Statistical Yearbook	1948~1950, 1952~1956, 1958~1978	1948, 1950, 1952~1956, 1958~1959: jpg files capturing some pages of books at the National Assembly Library 1949: an e-book from the website of the National Assembly Library. The rest: pdf files
The Busan Statistical Yearbook	1962~1978	1964, 1967: e-books from the National Archives of Korea 1973: e-book from the National Assembly Library The rest: e-books from the Busan Metropolitan City
The Gyeonggi Statistical Yearbook	1954~1955 1960~1965 1967~1978	1954~1955, 1960: e-books from the National Assembly Library The rest: pdf files
Statistical yearbooks of counties under the control of Gyeonggi Province	1966	Gapyeong, Suwon, Siheung, Anseong, Incheon, Paju, Pyeongtaek, Hwaseong: pdf files Ganghwa, Goyang, Gwangju, Gimpo, Bucheon, Yangju, Yangpyeong, Yeoju, Yeoncheon, Yongin, Uijeongbu, Icheon, Pocheon: jpg files capturing some pages of books from Statistics Korea Library
The Gangwon Statistical Yearbook	1958 1961~1965 1967~1978	1958 : a pdf file The rest: e-books from the Gangwon Province
Statistical yearbooks of counties under the control	1966	Gangneung: an e-book from the National Assembly Library Goseong, Sokcho, Jeongseon, Cheorwon, Chunseong, Chuncheon:

Data Sources	Publication Year	Form
of Gangwon Province		jpg files capturing some pages of books from Statistics Korea Library
The Chungbuk Statistical Yearbook	1961~1965 1967~1978	1961, 1963, 1968~1969: jpg files capturing some pages of books from the Statistics Korea Library The rest: e-books from the National Archives of Korea
Statistical yearbooks of Counties under the control of Chungbuk Province	1966	Goesan, Danyang, Boeun, Yeongdong, Okcheon, Eumseong, Jecheon, Jungwon, Jincheon, Cheongwon, Cheongju, Chungju: jpg files capturing some pages of books from Statistics Korea Library
The Chungnam Statistical Yearbook	1955~1958 1960~1965 1967~1978	Pdf files
Statistical yearbooks of counties under the control of Chungnam Province	1966	Gongju, Geumsan, Nonsan, Daejeon, Seosan: jpg files capturing pages of books from Statistics Korea Library
The Jeonbuk Statistical Yearbook	1957~1958 1960 1962~1965 1967~1978	1957~1958, 1960: e-books from the National Assembly Library 1962~1965, 1967 : e-books from the National Archives of Korea The rest: pdf files
Statistical yearbooks of counties under the control of Jeonbuk Province	1966	Gunsan, Gimje, Namwon, Muju, Buan, Okgu, Wanju, Iri, Iksan, Imsil, Jangsu, Jeongeup, Jinan: jpg files capturing some pages of books from the Statistics Korea Library Sunchang, Jeonju: e-books from the National Assembly Library
The Jeonnam Statistical Yearbook	1954~1955 1959 1963 1965 1967~1978	1954~1955, 1959: jpg files capturing pages of books from the National Assembly Library 1963: jpg files capturing some pages of books from the Suwon Library of Seoul National University 1965, 1967~1968: jpg files capturing pages of books from the Statistics Korea Library The rest: e-books from the National Archives of Korea
Statistical yearbooks of counties under the control of Jeonnam Province	1961	Mokpo: jpg files capturing pages of books from the Statistics Korea Library
	1964	Muan, Yeocheon, Yeonggwang, Jangheung: jpg files capturing pages of books from the Statistics Korea Library
	1966	Gwangsan, Gwangyang, Damyang, Muan, Suncheon, Yeocheon, Yeonggwang, Wando, Janheung, Jindo, Hampyeong, Haenam: jpg files capturing pages of books from the Statistics Korea Library
The Gyeongbuk Statistical Yearbook	1963~1965 1967~1978	1963, 1964: jpg files capturing pages of books from the Statistics Korea Library 1967: a pdf file. The rest: e-books in homepage of the National Archives of Korea
Statistical yearbooks of counties under the control of Gyeongbuk Province	1960	Pohang: jpg files capturing pages of books from the Statistics Korea Library
	1961	Daegu: jpg files capturing pages of books from the National Assembly Library Pohang: jpg files capturing pages of books from the Statistics Korea Library
	1962	Gyeongsan, Yeongju, Pohang: jpg files capturing pages of books from the Statistics Korea Library
	1966	Gyeongsan, Goryeong, Gunwi, Gimcheon, Dalseong, Bonghwa, Seongju, Andong, Yeongyang, Yeongil, Yeongju, Ulleung,

Data Sources	Publication Year	Form
		Wolseong, Cheongsong: jpg files capturing pages of books from the Statistics Korea Library
The Gyeongnam Statistical Yearbook	1961 1963~1965 1967~1978	1963: jpg files capturing pages of books from the Suwon Library of Seoul National University The rest: e-books from the National Archives of Korea
Statistical yearbooks of counties under the control of Gyeongnam Province	1958	Masan: an e-book from the National Assembly Library
	1966	Geoje, Geochang, Namhae, Sacheon, Sancheong, UIsan, Changnyeong, Changwon, Chungmu, Hadong, Haman: jpg files capturing pages of books from the Statistics Korea Library
The Jeju Statistical Yearbook	1961~1965 1967~1978	1961, 1963: jpg files capturing pages of books from the Statistics Korea Library 1962: jpg files capturing pages of books from the Suwon Library of Seoul National University The rest: e-books from the National Archives of Korea
Statistical yearbooks of counties under the control of Jeju Province	1966	Namjeju, Bukjeju, Jejusi: jpg files capturing pages of books from the Statistics Korea Library
Others		The Statistical Path of Gangwon (1993), the 50 Years of Wonju in the Sight of statistics (2005), the Statistical Path of Chungbuk (1996), the 50 Years of Daejeon in the sight of Statistics (1999): jpg files capturing pages of books from the Statistics Korea Library

These books provide comprehensive information on local statistics in the forms of figures and tables regarding: 1) short history, 2) land area and climate, 3) population, 4) industry and economy including agriculture, 5) public employees and finance, 6) water works, health, and cleaning, 7) social welfare, 8) education, 9) public peace, 10) price and national account, 11) communication and electric power, 12) foreign trade and exchange, 13) justice of their territories and 14) international statistics. More recent statistical yearbooks provide more detailed information with improved physical design in statistical figures and tables. However, the basic contents and structure remained unchanged over time. Table 2.4 presents common variables contained in statistical yearbooks of various provinces and years. Figures 2.1, 2.2, and 2.3 show the contents of tables about land area, population, and agriculture including livestock from a Seoul Statistical Yearbook.

〈Table 2.4〉 Information in Statistical Yearbooks Related to Land, Population, and Agriculture

Category	Contents
Land area	Location Land area by county Land area by land type Land area by land owner (public/ private)
Population	Growth of population House and population by county Population by sex Population by age and sex Population by education level Population by occupation Registered foreigner Movement of population
Agriculture	Number of farm house and farm population Food grain production: rice, barley and wheat, miscellaneous grains, pulse, potatoes, vegetables, fruits, special crops, medicinal plants, tobacco Farm environment: agricultural machines, chemicals, fertilizers Farm disaster Agricultural economy policy: agricultural cooperative federation, farmland improvements, New Community (Saemaul) Movement, government purchase of food grains Livestock things: number of livestock heads by animal type, livestock slaughtered, infectious disease of livestock, veterinarians, improvements of livestock environment

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III. POPULATION

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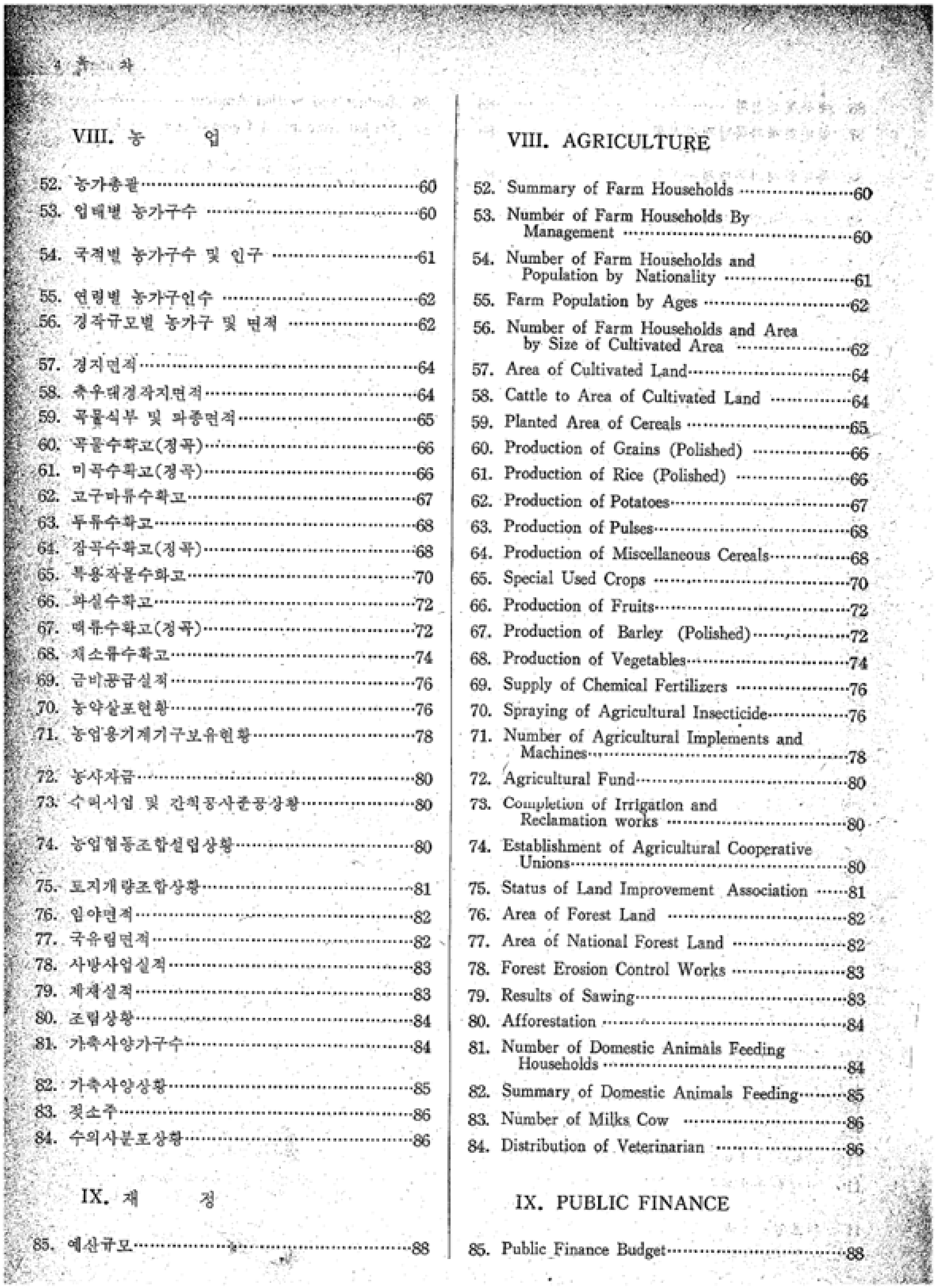
〈Figure 2.2〉 Contents of the 1970 Seoul Statistics Yearbook



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IX. 재 정

VIII. AGRICULTURE

IX. PUBLIC FINANCE

〈Figure 2.3〉 Contents of the 1970 Seoul Statistics Yearbook (Continued)

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63. 두 류 수 확 고

단위 : 면적…단보, 단수…kg, 수량…M/T

항 목	총계 Grand total			대두 Bay bean			소두 Red bean			녹두 Green bean		
	면적 Area	단수 Production per dan	수확량 Production	면적 Area	단수 Production per dan	수확량 Production	면적 Area	단수 Production per dan	수확량 Production	면적 Area	단수 Production per dan	수확량 Production
1965	7 291	75	543,2	4 816	83	402,0	826	63	61,8	169	48	8,1
1966	4 658	73	340,2	3 379	77	260,8	443	61	27,1	138	53	7,3
1967	3 610	74	263,7	2 934	79	225,9	374	58	21,8	83	54	4,6
1968	2 883	68	196,3	2 471	70	166,0	292	62	18,2	71	52	3,7
1969	**2 700**	**75**	**202,6**	**2 112**	**80**	**167,9**	**349**	**64**	**22,2**	**101**	**56**	**5,7**
종로	—	—	—	—	—	—	—	—	—	—	—	—
중구	—	—	—	—	—	—	—	—	—	—	—	—
동대문	56	70	3,9	41	69	2,9	14	67	0,9	—	—	—
성동	954	70	67,7	691	74	51,2	179	65	11,7	36	59	2,1
성북	31	72	2,2	25	75	1,8	3	59	0,2	3	54	0,2
서대문	72	48	3,4	9	115	1,0	3	130	0,4	2	130	0,3
마포	—	—	—	—	—	—	—	—	—	—	—	—
용산	—	—	—	—	—	—	—	—	—	—	—	—
영등포	1 587	79	125,4	1 346	82	111,0	150	60	9.0	60	52	3,1

자료 : 산업국 농정과

64. 잡 곡 수 확 고 (정곡)

단위 : 면적…단보, 단수 : kg, 수량…M/T

항 목	총계 Grand total			조 Millet			수수 Sorghuom			옥
	면적	단수 Production per dan	수확량 Production	면적 Area	단수 Production per dan	수확량 Production	면적 Area	단수 Production per dan	수확량 Production	면적 Area
1965	2 273	78	176,9	996	86	86,0	438	84	36,7	206
1966	1 334	69	91,4	502	70	34,9	469	73	34,1	141
1967	699	81	56,6	178	83	41,7	267	92	24,5	117
1968	564	68	38,1	167	64	10,7	176	72	12,7	105
1969	**523**	**69**	**36,1**	**75**	**74**	**5,5**	**242**	**68**	**16,5**	**144**
종로	—	—	—	—	—	—	—	—	—	—
중구	—	—	—	—	—	—	—	—	—	—
동대문	18	85	1,5	1	100	0,1	—	—	—	17
성동	228	72	16,4	43	83	3,5	72	73	5,3	57
성북	21	66	1,4	—	—	—	3	59	0,2	18
서대문	57	85	4,9	10	78	0,8	38	100	3,8	6
마포	—	—	—	—	—	—	—	—	—	—
용산	—	—	—	—	—	—	—	—	—	—
영등포	199	60	11,9	21	53	1,1	129	56	7,2	46

자료 : 산업국 농정과

〈Figure 2.4〉 Sample Table Used for Inputting Data: Part of the 1969 Seoul Statistical Yearbook

We selectively inputted the statistics regarding land area, population, and agriculture including livestock that are most crucial for our empirical analyses for constructing data on agricultural productions and nutritional availability by year, province and county. Nation-wide data by year were created by summing up province level data of same years. The Korea Statistical Yearbook and The Food, Agriculture, Forestry and Fisheries Statistical Yearbook were used as secondary sources to input nation-wide and province-specific statistics that are missing from provincial or county statistical yearbooks. Table 2.5 introduce the variables regarding agricultural productions and nutritional availability that were inputted to our dataset.

〈Table 2.5〉 Variables Inputted into Dataset on Agricultural Output and Nutritional Availability

Category	Contents	Unit
Year	Survey year	
Region	Entire nation, names of provinces and counties	
Land area	Land area by year and locality	m2
Population	Total, male, female population by year and region Population by age interval and sex for each year and region	
Agriculture : Food grains	Farm population by year and region	
	Farm house by type of management of farm land for each year and region: Paddy field, upland (dry field), fruits, vegetables, special crops, slash-and-burn field, livestock, sericulture, bee-raising, horticulture, wage earner	
	Rice: cultivated area and output by year and region	m2andkg,respectively
	Barley and wheat: cultivated area and output by year and region Barley, naked barley, wheat, rye	〃
	Miscellaneous grains: cultivated area and output by year and region Foxtail millet (jo), barnyard millet (Pi), common millet (Gijang), sorghum (susu), corn, buck wheat (memil), oatmeal	〃
	Pulse: cultivated area and output by year and region Soy bean, red bean, green been, kidney bean, pea, peanut	〃
	Potato and sweet potato: cultivated area and output by year and region	〃
	Vegetables: cultivated area and output by year and region Radish, Chinese cabbage (Baechu), cabbage (Yangbaechu), sweet melon (Chamoi), cucumber, eggplant (Gaji), pumpkin, watermelon, tomato, red pepper (Gochu), welsh onion (Pa), garlic, spinach, onion, taro (Toran), water parsley (Minari), burdock (Ueong), carrot, ginger, strawberry, asparagus, lettuce (Sangchu), head lettuce (Gyeolgusangchu), crown daisy (Ssukgak), salary, Chinese leek (Buchu), cabbage lettuce (Yangsangchu), lotus root, pepper (Pimang), parsley, greenhouse melon, outdoor melon, seasoned cabbage (Bomdong), rakkyo, haruna, Chinese yam (Ma), curled mallow (Auk), beet greens (Geundae), bellflower root (Doraji), bourd (Bak)	〃
	Fruits: cultivated area and output by year and region Apple, pear (Bae), Persimmon (Gam), grape, peach, plum (Jadu), apricot (Salgu), mandarin, pineapple, Korean cherry (Aengdu), cherry, Japanese apricot (Maesil), chestnut (Bam), jujube (Daechu), yuja, Japanese persimmon (Dangam), loquat (Bipa), quince (Mogwa), fig (Muhwagwa),	〃

Category	Contents	Unit
	pomegranate (Seokryu)	
Agriculture : livestock	Livestock breeding Cattle, milk cow, beef cattle, horse, pig, goat, rabbit, chicken, duck, goose, dog, turkey, bee, sheep, deer, pheasant, hawk (Mae), donkey, mule	Unit (Bee: box)
	Livestock slaughtering Cow, pig, chicken, horse, goat, dog, rabbit	Unit, kg

The land areas and agricultural outputs are originally reported in various units that were traditionally used in Korea. We converted these into meter-units that are currently used (see Appendix). We then converted the physical quantities of agricultural outputs into the magnitudes of calories and particular nutrients, using the information on calorie and nutrition ingredient per 100 gram of variety of foods reported in the Korean Food Composition Table that is available on the website of the National Institute of Agricultural Sciences (koreanfood.rea.go.kr). Table 2.6 presents calories and nutrition ingredients per 100g of selected foods in our dataset. As a result of this process, we created county- and province-level variables on the availability of total calories, carbohydrate, protein, fat, calcium, phosphorus, iron, kalium, natrium, vitamin A, vitamin B1, vitamin B2, vitamin B3, and vitamin C.

〈Table 2.6〉 Calorie and Nutrition Ingredient per 100g of Each Food in Agricultural Output and Nutritional Availability Dataset

Food	Detailed	Calorie (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Kalium (mg)	Natrium (mg)	Vitamin A (RE)	Vitamin B1 (mg)	Vitamin B2 (mg)	Vitamin B3 (Niacin) (mg)	Vitamin C (mg)
Rice	White rice	363	79.5	6.4	0.4	7	87	1.3	170	8	1	0.23	0.02	1.2	0
Barley		352	78	10	1	24	129	1.7	270	18	0	0.27	0.07	1.4	0
Naked barley		347	77.7	9.9	0.6	19	72	1.4	270	5	0	0.41	0.04	0.9	0
Wheat		333	75.8	10.6	1	52	254	4.7	538	17	0	0.43	0.12	2.4	0
Rye	Whole rye	334	70.7	15.9	1.5	10	378	6.4	501	2	0	0.26	0.16	1.8	0
Foxtain millet	Nonglutinous millet	386	76	9.7	4.2	11	184	2.3	368	3	0	0.21	0.09	1.5	0
Barnyard millet		367	72.4	9.7	3.7	7	280	1.6	240	3	0	0.05	0.03	2	0
Common millet		357	74.6	11.2	1.4	14	226	2.8	233	6	0	0.42	0.09	2	0
Sorghum		364	74.1	9.5	2.6	14	290	2.4	410	2	0	0.1	0.03	3	0
Corn	Glutinous corn	142	29.4	4.9	1.2	21	131	2.2	370	1	9	0.25	0.11	2.6	0
Buck wheat		374	74.7	11.5	2.3	18	308	2.6	477	14	17	0.46	0.26	1.2	0
Soy bean		420	30.7	36.2	17.8	245	620	6.5	1340	2	0	0.53	0.28	2.2	0
Red bean		356	68.4	19.3	0.1	82	424	5.6	1180	1	0	0.54	0.14	3.3	0
Green bean		354	62	22.3	1.5	100	335	5.5	1323	2	12	0.4	0.14	2	0
Kidney bean		169	29.2	10	1.2	62	97	3.7	732	5	0	0.48	0.11	1.6	4
Pea		79	13.2	5.8	0.3	25	134	1.6	356	13	1	0.01	0.09	0.8	12
Peanut		568	26	24.5	45.1	68	409	6.7	898	7	5	0.4	0.1	3	6
Potato		63	13.9	2.4	0	14	117	4.2	556	21	1	0.26	0.04	0.4	8
Sweet potato		131	31.2	1.4	0.2	24	54	0.5	429	15	19	0.06	0.05	0.7	25
radish	Joseon radish, root	21	4.6	1	0.1	26	38	2.3	257	43	0	0.11	0.03	0.5	15
Chinese cabbage		12	2.7	1.1	0	29	18	0.5	222	15	1	0.2	0.03	0.4	10
Cabbage		20	4.4	1.4	0.1	31	29	0.5	206	16	24	0.07	0.01	0.4	9
Sweet melon		38	7.5	2.2	0.4	6	79	0.3	663	10	6	0.07	0.03	0.6	21
Cucumber	Native	11	2.3	0.8	0.1	26	33	0.2	162	5	30	0.03	0.03	0.2	10
Eggplant		17	4	0.8	0.1	18	24	0.2	189	0	63	0.18	0.03	0.4	2
Pumpkin	Green pumpkin	26	5.6	0.9	0.1	30	36	0.4	215	17	34	0.16	0.02	0.4	9
Watermelon		32	8.1	0.8	0	5	14	0.5	169	1	31	0.06	0.01	0.3	0
Tomato		18	4.5	0.8	0	6	12	0.5	196	16	12	0.04	0.01	0.5	12

Food	Detailed	Calorie (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Kalium (mg)	Natrium (mg)	Vitamin A (RE)	Vitamin B1 (mg)	Vitamin B2 (mg)	Vitamin B3 (Niacin) (mg)	Vitamin C (mg)
Red pepper	Dried	300	50.6	11	11	58	230	6.8	2930	56	4623	0.3	1.1	12.5	26
Welsh onion		29	6.7	1.2	0.2	25	26	1	239	17	1	0.02	0.04	0.3	11
Garlic	Green garlic	40	7.6	2.7	0.2	48	79	11	435	30	21	0.3	0.11	0.5	48
Spinach		33	6	3.1	0.5	40	29	2.6	502	54	479	0.12	0.34	0.5	60
Onion		36	8.4	1	0.1	16	30	0.4	144	2	0	0.04	0.01	0.1	8
Carrot		37	8.6	1.1	0.1	40	38	0.7	395	30	1270	0.06	0.05	0.8	8
Apple	Busa	49	13.1	0.2	0.1	6	9	0.3	146	16	1	0.05	0.03	0.5	48
Pear	Singo	41	10.9	0.3	0.1	2	11	0.2	171	3	0	0.02	0.01	0.1	4
Persimmon	Daebong	70	18.9	0.6	0	18	23	3.6	214	2	40	0.06	0.07	0.5	18
Grape	Campbell early	46	12.2	0.5	0.1	5	13	0.2	165	0	2	0.06	0.01	0.2	0
Peach	White peach	36	9.1	0.6	0.1	5	19	0.1	190	2	0	0.03	0.02	0.7	0
Mandarin	Native	39	9.9	0.7	0.1	13	11	0	173	11	1	0.13	0.04	0.4	44
Beef	Native, lean meat, uncooked	190	0.6	19.3	11.3	14	154	3.6	277	259	4	0.06	0.21	4.1	0
Pork	Lean meat, uncooked	241	0.4	17.8	17.5	5	179	2.1	51	17	4	0.78	0.19	4.5	0

Source: The 8thRevisionoftheStandardFoodCompositionTable(Publishedin2013)

How accurate are these data on agricultural productions? Given that some of these sources were produced more than five decades ago when Korea was a poor country recovering from the war-caused destruction, there are questions about the credibility of the sources we relied upon (for example, see Go 2007 and Hwang et al. 2014). Agents conducting public statistical works at the time perhaps lacked proper skills and knowledge compared to current government employees. There might be some inconsistencies in the methods of producing statistics across different years and regions.

Having said that, we believe the quality of our dataset on agricultural productions is comparable to that of other historical data of its kind. We attempted to find and correct errors contained our sources as much as possible. For instance, we crosschecked among different sources providing the same statistics, discovered typos, and differentiated between 0 and missing values. We also examined if our data reveal any discontinuous year-by-year changes that cannot be explained fluctuations in agricultural productions (e.g. natural disasters or poor crop yields). The results of these examinations suggest that there is no reason to believe that the quality and credibility of the data are highly questionable. Although constrained by lack of resources and manpower, it appears that the central and local authorities tried their best to produce accurate and consistent statistics that were critical for planning and implementing national and regional policies. At the least, the records we utilized are the most reliable sources of local food productions that are available. For these reasons, we cautiously claim that our data can provide reasonably reliable estimates of local food availability in South Korea from 1950 to 1980.

Methods

Measuring Nutritional Status during Growth Periods

Adult stature is associated with the quantity and quality of diet during periods of human growth, along with other environmental factors such as exposure to disease. Two growth periods are particularly important for determining adult height: early childhood from conception to 2 years of age, and early adolescence before the onset of puberty. For boys, the second growth spurt occurs between age 12 and 16, whereas it begins early for girls (Abbassi 1998). The most crucial period when adult height is determined is the first growth period in early childhood. The second growth period provides an opportunity for “catch-up growth,” defined as a more rapid growth than normal for age that follows a period of retardation in early growth. It is widely accepted that catch-up growth is insufficient to fully make up for deficiencies in early childhood (Perkins et al. 2016). To investigate the association between nutrition and height, accordingly, we estimated measures of nutritional intakes separately for two crucial periods of human growth: the first four years in early childhood from conception to age 3 and the five years in early adolescence from age 12 to age 16.

Currently available data do now allow us to connect the adult height of a person to his or her detailed dietary history during growth. Previous studies infer the amount of nutritional intakes from available data on food productions in particular country or region to establish the relationship between nutritional status and health outcomes in the past. Lindert (1994) estimated per capita food consumption in Britain from 1700 to 1850 combining estimates of food productions in England and Wales and statistics on Britain’s imports and exports of food items. Floud et al. (2011) estimated average number of calories for consumption per capita per day in England and Wales from 1700 to 1909-13, based on crop yields estimated by other scholars. Haines et al. (2003) computed calories and protein productions per adult equivalent per day in each county in the mid-19thcenturyUnitedStates,utilizingcounty-levelstatisticsonfarmoutputsreportedintheU.S.AgriculturalCensus.Thesestudiesusedtheestimatesoffoodconsumptionasmeasuresofstandardoflivingand determinantsofhealthoutcomessuchasheightandmortality.

Following the spirit of previous works on the issue, we inferred nutritional intakes of the conscripts in our sample from the information on food productions in the locality (either county or province) where they lived in early childhood and in adolescence. More specifically, we estimated the total calories and the amounts of major nutrients (including protein, fat, and carbohydrate) for the years covering the early childhood (from conception to age 3) and early adolescence (from age 12 to age 16). As discussed in Chapter 3, county-level statistics on agricultural productions are regularly available only from 1960. Thus, we were unable to obtain county-level measures of nutritional availability in early childhood to be matched to our conscript sample born from 1946 to 1950. We managed to find provincial data on agricultural productions from 1950 on regular basis. Using these sources, we estimated provincial nutritional availability in early childhood for the individuals born from 1951 to 1957. County-level variables pertaining to nutritional availability in early adolescence are computed for the entire 1946-1957 birth cohorts.

Nutritional requirements differ by gender and age. According to an estimate, for example, girls aged 5 to 9 require two thirds of calories needed by males aged 20 to 39 (Fogel 1993). Given the considerable regional variations in population composition, per capita productions may be misleading measures of true local nutritional availability. For this reason, we converted the county or provincial population into adult (prime-age: 20 to 39) male equivalent population, using the estimated average calorie consumption of each age-gender group as a proportion of that of males aged 20 to 39 (Fogel 1993, p. 9). In the above example, a girl aged 5 to 9 is counted as 0.6667 adult male. Age- and gender-specific population of each county and province was used for this computation.

Using the aforementioned calories or amounts of nutrients per adult male equivalent population as an index of food availability implicitly assumes that a person's diet is strongly influenced by the size of locally produced nutrients. However, nutrients could be purchased from other regions if they were not sufficiently produced locally. In particular, urban areas are typically net importers of nutrients even in the past when agricultural markets were not well integrated. The size of nutritional production per adult equivalent should be extremely low in large cities, such as Seoul and Busan, where only a small fraction of residents are food producers. Although it is a matter of debate, it is likely that the market for nutrients in mid-20th-century Korea was more tightly integrated than the U.S. agricultural market in the mid-19th-century where the conventional measure of local nutritional availability was applied (Haines et al. 2003).

We circumvented this problem in the following ways. Firstly, we used calories and amounts of major nutrients per farm household male equivalent population (instead of the entire adult male equivalent population) in each county or province as our primary measure of local nutritional availability. Secondly, we used several alternative subsamples whose diet was more likely influenced by local food productions. These subsamples include individuals from counties with their nutritional productions per farm household population above a minimum threshold, men from rural counties, and children of farmers in rural counties. These methods are expected to allow us to reduce the problem of understating food availability in large cities. The size of food production per farm household could be regarded as a crude index of agricultural productivity as well as nutritional availability in the locality. If locally produced nutrients were exported to other regions, rural counties with a high agricultural productivity could still benefit from increased incomes. To sum up, our basic assumption is that a rise in food production per standardized farm household population in a locality improves nutritional status of it residents either through increased food availability or through increased income.

Our measures of nutritional availability are explained in Table 3.1. Proxy variables indicating food availability in fetus and infancy include average productions of calories (Calories, Infancy), protein (Protein, Infancy), fat (Fat, Infancy), and Carbohydrate (Carbohydrate, Infancy) for 4 years (from the year of birth -1 to the year of birth + 2) in the province of residence per farm household adult male equivalent per day. Similarly, proxy variables for food availability in adolescence include average productions of calories (Calories, Adolescence), protein (Protein, Adolescence), fat (Fat, Adolescence), and Carbohydrate (Carbohydrate, Adolescence) for 5 years (from age 12 to age 16) in the county of residence per farm household adult male equivalent per day. Calories and the three major nutrients per adult male equivalent (where the number of the entire population was applied instead of the number of farm household population) were also employed in our analyses for robustness check.

〈Table 3.1〉 Definition of Variable

Variable	Definition
Height	Height at age 20 (in centimeter)
Food availability in fetus & infancy	
Calories, Infancy	Average calorie production for 4 years (from prenatal period to age 2) in the province of residence (1000s of kcals per farm household adult male equivalent per day).
Protein, Infancy	Average protein production for 4 years (from prenatal period to age 2) in the province of residence (100s of grams per farm household adult male equivalent per day).
Fat, Infancy	Average fat production for 4 years (from prenatal period to age 2) in the state of residence (100s of grams per farm household adult male equivalent per day).
Carb, Infancy	Average carbohydrate production for 4 years (from prenatal period to age 2) in the state of residence (100s of grams per farm household adult male equivalent per day).
Food availability in adolescence	
Calories, Adolescence	Average calorie production for 5 years (from age 12 to age 16) in the county of residence (1000s of kcals per farm household adult male equivalent per day).
Protein, Adolescence	Average protein production for 5 years (from age 12 to age 16) in the county of residence (100s of grams per farm household adult male equivalent per day).
Fat, Adolescence	Average fat production for 5 years (from age 12 to age 16) in the county of residence (100s of grams per farm household adult male equivalent per day).
Carb, Adolescence	Average carbohydrate production for 5 years (from age 12 to age 16) in the county of residence (100s of grams per farm household adult male equivalent per day).
Environmental characteristics	
Population density	Population (100s of persons) per 1 square kilometers in the county of residence at age 14.

Variable	Definition
Nonfarm population share	The share of nonfarm population (percent) in the county of residence at age 14.
Seasonality of birth	
First quarter	Equals 1 if born from January to March.
Second quarter	Equals 1 if born from April to June.
Third quarter	Equals 1 if born from July to September.
Fourth quarter	Equals 1 if born from October to December.
Family size	
Number of family 1-3	Equals 1 if two or less family members are reported.
Number of family 4-6	Equals 1 if three to five family members are reported.
Number of family 7 or more	Equals 1 if six family members are reported.
Father's occupation	
Professional	Equals 1 if father had a professional or managerial job.
Clerical	Equals 1 if father had a semi-professional or clerical job.
Service	Equals 1 if father had a service job.
Farming	Equals 1 if father's occupation was farmer.
Manual	Equals 1 if father had a manual job.
No job reported	Equals 1 if father's job is not reported.
Father absent	Equals 1 if father was absent.

Other Explanatory Variables

In addition to access to food, environmental factors such as prevalence of diseases and sanitary conditions are important determinants of adult height. Previous historical studies suggest that population and urbanization were closely related to shorter stature and higher mortality in the U.S., Britain, and other advanced countries until the early 20th century (Fogel 1991; Wilson and Pope 2003; Haines et al. 2003; Cain and Hong 2009). In the mid-nineteenth century U.S., for example, residents in rural areas were about 2 inches taller than city dwellers. The advantages of living in countryside in the past were largely attributed to greater isolation from other people that reduced the chances of exposure to infectious diseases and better access to high-quality foods. Increased pollutions caused by industrialization and inflow of city-bound migrants, and policy failures in providing proper public health measures and additional housing in the early stage of urbanization are also blamed for the highly unhealthy living conditions in urban areas in the past. It is not entirely clear if this was the case in South Korea in the 1950s and 1960s. Given that there are potential positive aspects of urbanization, such as higher wages and closer access to markets and medical services, it is an empirical question how urbanization and industrialization were associated with the heights of Koreans born in the mid-20th century. In this study, we included as proxies capturing local environmental characteristics the following two variables: population density (100s of persons per one square kilometer) and the percentage of nonfarm population in the county where the conscript lived at age 14.

The information on conscripts and their family members kept in military records allows the inclusion of characteristics that affected their early life. First, dummy variables indicating the season of birth were constructed based on each conscript's date of birth. Previous studies have established that season of birth is significantly related to later outcomes including adult height, perhaps due to seasonal variations in-utero conditions such as nutrition and maternal exposure to disease. In the Northern Hemisphere, in general, individuals born in winter/spring are significantly taller than the average of their birth cohort, whereas those born in the final three months of the year are significantly shorter (McGrath et al. 2006; Tanaka et al. 2007). In our analyses, seasons of birth were classified into four quarters, January to March, April to June, July to September, and October to December.

Second, family size was considered as a potential determinant of within-family allocation of nutrients. Previous studies suggest that a larger number of family members, particularly siblings, tend to reduce parental investments in children (Conley and Glauber 2006; Lee 2008). The format of Korean Military Records makes it difficult to determine the exact family size or the members or siblings. The table concerning family information has only six lines, allowing up to six other family members to be reported. In selecting family members to be included, it appears that the priority was given to parents and grandparents (if alive), and then siblings. Thus, it is likely that some siblings failed to be reported for conscripts from large families. For these reasons, we included in the analysis the following categorical variables on family size: one to three, four to six, and seven or more.

Korean Military Records provide a rare opportunity to connect a person's adult height to parental characteristics. Taking advantage of this unusual feature of our data, we included father's occupation as an index of socioeconomic conditions during childhood and adolescence. Because our data sources were created when the individuals in our sample were around age 20, many of their fathers were presumably dead or retired by the time they were conscripted. Indeed, a considerable proportion of conscripts did not provide information on their fathers. Given the importance of the household head in Korea at the time, it is likely that the majority of them survived their fathers. For about one third of the individuals in our sample, father's occupation is not reported, although other paternal characteristics (such as relationship or age) are given. It is unknown if those fathers were out of the labor force or if their jobs failed to be reported. In our analyses below, father's occupation was classified into the following categories: professional, clerical, service, farming, manual, no job reported, and father absent.

Military records provide conscripts' personal characteristics, too. The most comprehensively reported is conscripts' educational attainment: it is missing for only 0.5% of the sample. Children's education is a useful indicator of parental economic status or their investment in children. However, causal relationship between education and height is not straightforward. It is widely accepted that cognitive ability, school attendance, and academic performances can be influenced by nutritional status in early childhood. A study even suggests that height at age 16 is a marker of cognitive ability (Case and Paxson 2008). Thus, inclusion of own education in height regression is subject to a reverse causality problem. For this reason, we did not include education in our baseline regressions. Instead, education variable was employed only in robustness tests where education is classified into the following five categories: primary school or less, middle school, high school, college or more, and education missing.

Sample Selection

Table 3.2 compares the measures of food availability and other personal and family characteristics across six selected samples. There are 17,833 conscripts in the sample who were born between 1946 and 1957 and whose date of birth is completely recorded. This sample is defined as the full sample (Col. 1). Of these men, height was successfully identified for 16,838 individuals (Col. 2). Another major sample losses occurred when selecting individuals with information on county of residence. 13,034 persons survived this selection process. Failure of identifying height or county of residence resulted large from the poor conditions of the original carded military records. The most important predictor of the probability that height or county of residence is unidentified is the year of conscription: the earlier the records produced the higher the chances of failure.

〈Table 3.2〉 Comparison of Selected Samples

	(1) Full Sample	(2) Information on height	(3) Height + County (nutrition in adolescence)
Measure of net nutritional status			
Height (centimeter)		166.446	166.408
Food availability in fetus & infancy			
Calories (1000s of Kcal)			
Protein (100s of grams)			
Fat (100s of grams)			
Carbohydrate (100s of grams)			
Food availability in adolescence			
Calories (1000s of Kcal)			4.380
Protein (100s of grams)			1.211
Fat (100s of grams)			0.270
Carbohydrate (100s of grams)			8.987
Environmental characteristics			
Population density (100s/km2)			20.298
Nonfarm population share (%)			45.661
Seasonality of birth (proportion)			
First quarter	0.286	0.284	0.284
Second quarter	0.230	0.231	0.232
Third quarter	0.242	0.242	0.238
Fourth quarter	0.242	0.242	0.246
Family size (proportion)			
Number of family 1-3	0.096	0.092	0.087
Number of family 4-6	0.609	0.611	0.610
Number of family 7 or more	0.295	0.297	0.303
Father’s occupation (proportion)			
Professional	0.007	0.007	0.006
Clerical	0.024	0.024	0.022
Service	0.005	0.005	0.005
Farming	0.391	0.389	0.415
Manual	0.023	0.023	0.022
No job reported	0.341	0.343	0.328
Father absent	0.204	0.204	0.328
Own education (proportion)			
Primary school or less	0.239	0.242	0.254
Middle school	0.282	0.283	0.287
High school	0.363	0.363	0.355
College	0.112	0.108	0.101
Education missing	0.004	0.004	0.003
Number	17833	16838	11508

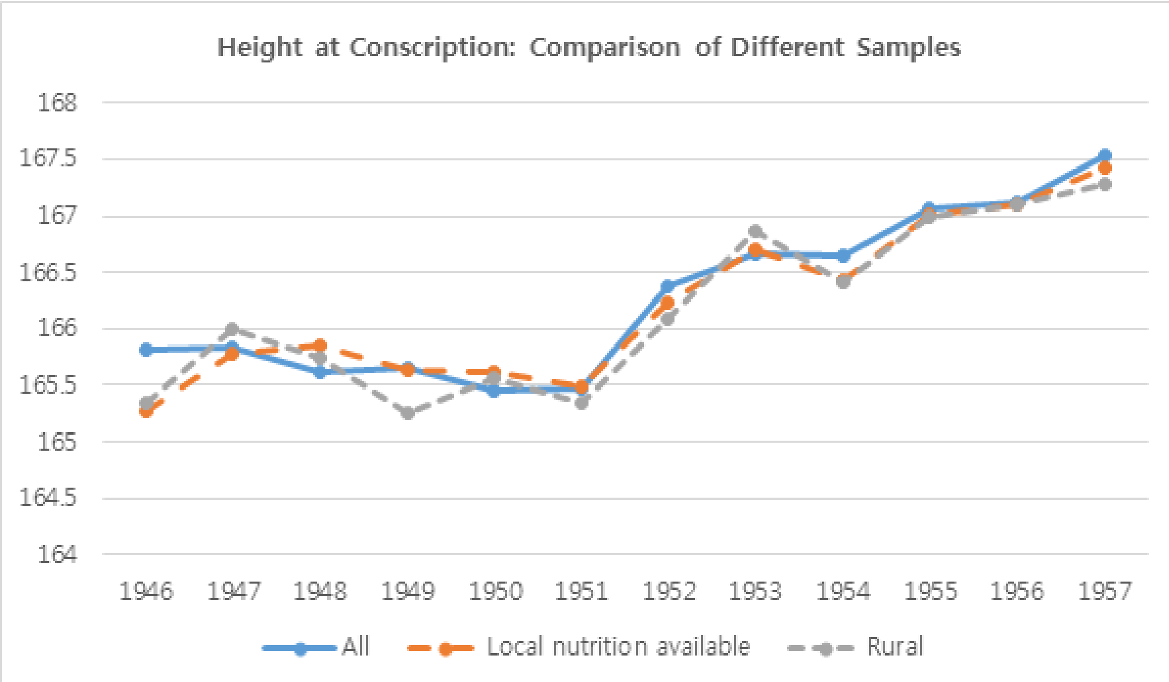
〈Table 3.2〉 Comparison of Selected Samples

	(4) Rural counties	(5) Rural counties, 1951-1957 cohorts	(6) Farmer's sons in rural counties, 1951-1957 cohorts
Measure of net nutritional status			
Height (centimeter)	166.338	166.656	166.731
Food availability in fetus & infancy			
Calories (1000s of Kcal)		2.811	2.880
Protein (100s of grams)		0.698	0.714
Fat (100s of grams)		0.113	0.115
Carbohydrate (100s of grams)		5.958	6.107
Food availability in adolescence			
Calories (1000s of Kcal)	4.662	5.090	5.132
Protein (100s of grams)	1.146	1.257	1.248
Fat (100s of grams)	0.187	0.207	0.195
Carbohydrate (100s of grams)	9.921	10.832	10.960
Environmental characteristics			
Population density (100s/km2)	4.663	5.155	3.181
Nonfarm population share (%)	25.922	26.240	22.490
Seasonality of birth (proportion)			
First quarter	0.287	0.284	0.290
Second quarter	0.234	0.235	0.229
Third quarter	0.235	0.234	0.238
Fourth quarter	0.244	0.247	0.243
Family size (proportion)			
Number of family 1-3	0.077	0.064	0.023
Number of family 4-6	0.601	0.614	0.600
Number of family 7 or more	0.321	0.322	0.377
Father's occupation (proportion)			
Professional	0.004	0.004	0
Cleric	0.016	0.018	0
Service	0.003	0.003	0
Farming	0.512	0.501	1.000
Manual	0.013	0.015	0
No job reported	0.260	0.279	0
Father absent	0.189	0.177	0
Own education (proportion)			
Primary school or less	0.295	0.281	0.299
Middle school	0.306	0.307	0.323
High school	0.329	0.343	0.329
College	0.067	0.067	0.048
Education unreported	0.003	0.001	0.001
Number	7850	5560	2784

Source. Sample of Korean Military Records matched with province- and county-level data on nutritional availability.

We selected additional subsamples for regression analyses. Variables on nutritional availability could not be computed in a few counties. We also excluded counties with limited agricultural productions (average calorie production per farm household adult male equivalent per day was less than 1000 Kcals in adolescence) and those with extremely high productions (average calorie production per farm household adult male equivalent per day exceeded 20,000 Kcals in adolescence). About 2,500 men who lived in those counties between age 12 and 16 were excluded from the sample, leaving us with 11,508 individuals (Col. 3). This sample with information on height and county-level information on nutritional availability in adolescence is not much different from the full sample in terms of personal and family characteristics, although the latter is slightly less educated and more likely to include fathers' sons.

We further restricted our sample to 7,850 individuals from rural counties with information on height and nutritional availability in adolescence (Col. 4). The excluded urban areas are the districts in metropolitan cities including Seoul, Busan, Incheon, Daejeon, Gwangju, and Daegu. Since large cities were excluded, it is not too surprising that this sample presents a much lower population density and a higher nonfarm population share compared to the full sample. In addition, family size is larger, fathers are more likely to be farmer, and schooling is lower in the sample compared to the full sample. We made an additional selection to have our baseline sample of 5,560 men from rural counties who born between 1951 and 1957 (Col. 5). The 1946 to 1950 birth cohorts were excluded to include both nutritional availability in infancy and adolescence in regressions, as the variables on nutritional productions in infancy are available only for the 1951 to 1957 birth cohorts. Finally, we used a subsample of 2,784 persons from rural counties who were born between 1951 and 1957 and whose father was farmer (Col. 6). We used this sample in the analysis to account for the fact that farmers' children were perhaps most strongly influenced by changes in nutritional production per farm household population.



〈Figure 3.1〉 Height at Conscription: Comparison of Different Samples

Because of potential sample selection bias, the results from subsamples may not represent the experiences of the entire conscript population, let alone the young male population at large. Whereas the first three samples (Cols. 1 to 3) are generally similar with one another in terms of personal and family characteristics, the samples restricted to men from rural counties (Cols. 4 to 6) differ from the larger samples. However, except the noticeable differences in several characteristics that are fully expected from the nature of sample selection (such as lower population density and nonfarm population share as well as higher percentage of persons whose father is a farmer), the selected subsamples are reasonably comparable to the full sample in terms of height, nutritional availability, family size, and educational attainment. Figure 3.1 shows that the height changes across birth cohorts observed from three different samples (the full sample, the sample with county-level nutritional production is available, and the rural county sample) are remarkably similar.

Nutritional Availability and Height

Results of Baseline Regressions with a Rural County Sample

Our baseline regressions are based on the sample of 5,560 men from rural counties who were born between 1951 and 1957 and who have complete information on local nutritional availability in infancy and adolescence. Using this sample, we estimate the following equation:

$$(1)\ H_{i,j,c} = \beta_0 + \beta_1 N^I_{i,c} + \beta_2 N^A_{j,c} + \beta_3 Z_{j.c} + \beta_4 X_{i,j.c} + \varepsilon_{i,j,c}$$

In equation (1), $H_{i,j,c}$ is the height of *i*th person from *j*th county who belongs to *c*th birth cohort. $N^I_{j,c}$ and $N^A_{j,c}$, stand for vectors of variables on nutritional availability in infancy and in adolescence, $Z_{j,c}$ vector of variables on environmental conditions in county of residence at age 14, $X_{i,j,c}$ variables on family and personal characteristics, and $\varepsilon_{i,j,c}$ error term. Standard errors were clustered at county level.

〈Table 4.1〉 Local Nutritional Availability and Height: 1951–1957 Birth Cohort in Rural Counties

Variable	(1)	(2)	(3)	(4)
Intercept	165.4625***	165.2796***	166.4755***	165.4818***
	(0.3999)	(0.4309)	(0.3309)	(0.3945)
Local Nutritional availability				
Calories, Infancy	0.2546**			
	(0.0995)			
Calories, Adolescence	0.1303**			
	(0.0497)			
Protein, Infancy		1.3243***		
		(0.4415)		
Protein, Adolescence		0.5698***		
		(0.1941)		
Fat, Infancy			1.7949	
			(2.5847)	
Fat, Adolescence			1.5865*	
			(0.9061)	
Carbohydrate, Infancy				0.1186**
				(0.0458)
Carbohydrate, Adolescence				0.0585**
				(0.0226)
Local environment				
Population density	0.01689	0.0165	0.0120	0.0169
	(0.0121)	(0.0115)	(0.0113)	(0.0122)
Nonfarm population share	-0.0051	-0.0082	-0.0100	-0.0043

Variable	(1)	(2)	(3)	(4)
	(0.0084)	(0.0081)	(0.0070)	(0.0085)
Season of Birth				
First quarter	NI	NI	NI	NI
Second quarter	0.2235	0.2253	0.2134	0.2234
	(0.1791)	(0.1795)	(0.1773)	(0.1790)
Third quarter	-0.2126	-0.2019	-0.1925	-0.2141
	(0.1688)	(0.1682)	(0.1688)	(0.1689)
Fourth quarter	-0.3076	-0.3069	-0.3124	-0.3081
	(0.2109)	(0.2103)	(0.2113)	(0.2110)
Family size				
1 to 3	0.3611	0.3733	0.3368	0.3593
	(0.3377)	(0.3389)	(0.3400)	(0.3376)
4 to 6	NI	NI	NI	NI
7 or more	0.0169	0.0082	0.0115	0.0192
	(0.1494)	(0.1501)	(0.1516)	(0.1494)
Father's occupation				
Professional	-0.1198	-0.0932	-0.0897	-0.1262
	(0.9222)	(0.9256)	(0.9325)	(0.9211)
Clerical	1.0196**	1.0070**	1.0074**	1.0212**
	(0.4777)	(0.4787)	(0.4765)	(0.4774)
Service	-0.9528	-0.9629	-0.8128	-0.9545
	(1.6111)	(1.6141)	(1.6371)	(1.6100)
Farming	NI	NI	NI	NI
Manual	-1.2294**	-1.2309**	-1.2340**	-1.2296**
	(0.5973)	(0.5966)	(0.5923)	(0.5973)
No job	-0.2662	-0.2574	-0.2961*	-0.2667
	(0.1735)	(0.1730)	(0.1735)	(0.1736)
Father absent	-0.1025	-0.0935	-0.1079	-0.1044
	(0.2029)	(0.2026)	(0.2035)	(0.2030)
R-square	0.0075	0.0080	0.0051	0.0075
F-value	3.54***	3.75***	2.76***	3.53***
N	5560	5560	5560	5560

The results from estimating four versions of equation (1) including different types of nutrients, namely calories (Col. 1), protein (Col. 2), fat (Col. 3), and carbohydrate (Col. 4), are presented in Table 4.1. Except for fat, the variables on nutritional availability are all positive and statistically significant. The estimated coefficients indicate that a person who spent infancy in a province that produced calories per farm household population one standard deviation (0.711 Kcal) above the mean would have been 0.18 centimeters taller at age 20, if other things being equal. One standard deviation grater productions in protein in infancy (0.156) and carbohydrate in infancy (1.545) would increase adult height by 0.21 centimeters and 0.18 centimeters, respectively. The estimated coefficients for food availability in adolescence are smaller than those in infancy. However, the standard deviations for the former are larger than the latter. As a consequence, the effects of one standard deviation change in nutritional variables in adolescence and in infancy are similar in magnitude. One standard deviation increase in calories (1.547), protein (0.386), fat (0.107), and carbohydrate (3.421) in the counties where the conscripts spent adolescence was associated with an increase in height at age 20 by, respectively, 0.20 centimeters, 0.22 centimeters, 0.17 centimeters, and 0.18 centimeters.

The population density in the county of residence at age 14 is positively related to adult height, whereas the effect of nonfarm population share on height is negative; the coefficients for these two environment variables are statistically insignificant. The estimated birth season effect is anticipated one (positive for the second quarter and negative for the fourth quarter), but they are statistically insignificant. Men from families with three or less family members are about 0.35 centimeters taller than those with 4 to 6 families, but the effect of family size is statistically insignificant. The conscripts whose father was employed in a clerical job are about one centimeter taller than farmers' sons. Having a father engaged in a manual job decreased height by about 1.2 centimeters, compared to children of farmers.

Robustness

A major drawback of the data that our analyses are based upon is that the true place of birth is unknown. In estimating nutritional availability in infancy, it was implicitly assumed that the individuals in our sample remained in the same province from birth to conscription. Geographic moves would produce measurement errors in the nutrition variables that could attenuate their effects on height. To alleviate this potential measurement error, we used a subsample of men from rural counties whose province of residence at the time of conscription is the same as the province of "original family place (*Bonjeok*)." For the birth cohorts born in the 1940s and 1950s, it is likely that *Bonjeok* presents their fathers' place of birth or place of residence in the early Japanese Colonial period when the modern household registration system was first introduced. Thus, if a conscript's current address and *Bonjeok* are identical, it is likely that he was born in the current province of residence. Of the 13,999 men in our sample for whom both current address and *Bonjeok* are available, about 79 percent reported identical province. The percentage of match is even higher for the rural country sample (91%), which implies that prior geographic mobility of individuals who lived in rural areas at the time of conscription was probably low.

〈Table 4.2〉 Local Nutritional Availability and Height: 1951-1957 Birth Cohort in Rural Counties Living in Family Place

Variable	(1)	(2)	(3)	(4)
Intercept	165.3111***	165.1875***	166.5838***	165.3213***
	(0.4315)	(0.4544)	(0.3316)	(0.4264)
Local Nutritional availability				
Calories, Infancy	0.3010***			
	(0.1011)			
Calories, Adolescence	0.1370***			
	(0.0515)			
Protein, Infancy		1.4468***		
		(0.4478)		
Protein, Adolescence		0.5923***		
		(0.1973)		
Fat, Infancy			0.8730	
			(2.5709)	
Fat, Adolescence			1.7227*	
			(0.9057)	
Carbohydrate, Infancy				0.1414***
				(0.0465)
Carbohydrate, Adolescence				0.0617***
				(0.0234)
Local environment				
Population density	0.0124	0.0124	0.0074	0.0122
	(0.0128)	(0.0121)	(0.0125)	(0.0129)
Nonfarm population share	-0.0027	-0.0063	-0.008	-0.0018
	(0.0088)	(0.0084)	(0.0077)	(0.0089)
Season of Birth				
First quarter	NI	NI	NI	NI
Second quarter	0.2441	0.2464	0.2285	0.2438
	(0.1863)	(0.1866)	(0.1847)	(0.1861)
Third quarter	-0.3082*	-0.2946*	-0.2895	-0.3103*
	(0.1770)	(0.1765)	(0.1776)	(0.1771)
Fourth quarter	-0.3278	-0.3253	-0.3341	-0.3288
	(0.2224)	(0.2220)	(0.2231)	(0.2224)
Family size				
1 to 3	0.2778	0.2888	0.2407	0.2762
	(0.3754)	(0.3756)	(0.3760)	(0.3754)
4 to 6	NI	NI	NI	NI
7 or more	0.0031	-0.0071	0.0013	0.0058
	(0.1567)	(0.1575)	(0.1587)	(0.1566)
Father's occupation				
Professional	-0.2280	-0.1950	-0.1975	-0.2363
	(0.9485)	(0.9537)	(0.9639)	(0.9470)
Clerical	1.0219**	1.0046**	0.9870**	1.0244**
	(0.4641)	(0.4647)	(0.4610)	(0.4638)
Service	-0.9936	-0.9951	-0.8420	-0.9971
	(1.6016)	(1.6090)	(1.6370)	(1.5998)
Farming	NI	NI	NI	NI
Manual	-1.0202	-1.0169	-1.0368	-1.0226
	(0.7479)	(0.7487)	(0.7418)	(0.7476)
No job	-0.1854	-0.1806	-0.2363	-0.1855
	(0.1815)	(0.1812)	(0.1822)	(0.1816)

Variable	(1)	(2)	(3)	(4)
Father absent	-0.1714	-0.1653	-0.1860	-0.1733
	(0.2128)	(0.2122)	(0.2118)	(0.2129)
R-square	0.0078	0.0081	0.0047	0.0078
F-value	3.13***	3.19***	2.26***	3.15***
N	5044	5044	5044	5044

We estimated equation (1) with a subsample of 5,044 for whom the current and Bonjeok provinces are identical. We expect that this additional sample restriction can diminish the magnitude of measurement error arising from migration. The results are reported in Table 3.2. In general, the results are similar to those from the baseline regressions conducted with the full rural county sample. However, the estimated coefficients for nutritional availability, especially in infancy, are noticeably larger than those obtained from the entire rural county sample (Table 5.1). If these new estimates are applied, one standard deviation increase in calories (0.697), protein (0.154), and carbohydrate (1.516) in infancy would increase adult height by 0.21 centimeters, 0.22 centimeters, and 0.21 centimeters, respectively, slightly larger than the effects drawn from the full rural county sample.

〈Table 4.3〉 Local Nutritional Availability and Height: Controlling Own Education and Province Fixed Effect

Variable	(1)	(2)	(3)	(4)
(A) Education				
Calories, Infancy	0.2305**			
	(0.0977)			
Calories, Adolescence	0.0994**			
	(0.0497)			
Protein, Infancy		1.1955***		
		(0.4375)		
Protein, Adolescence		0.4731**		
		(0.1955)		
Fat, Infancy			1.7589	
			(2.6168)	
Fat, Adolescence			1.5002*	
			(0.9050)	
Carbohydrate, Infancy				0.1070**
				(0.0449)
Carbohydrate, Adolescence				0.0440*
				(0.0226)
Primary school or less	NI	NI	NI	NI
Middle school	0.8319***	0.8309***	0.8698***	0.8314***
	(0.1706)	(0.1707)	(0.1702)	(0.1705)
High school	1.4880***	1.4896***	1.5366***	1.4871***
	(0.1724)	(0.1721)	(0.1714)	(0.1724)
College	1.9143***	1.9163***	1.9549***	1.9147***

Variable	(1)	(2)	(3)	(4)
	(0.2998)	(0.2994)	(0.2996)	(0.2998)
Education Missing	3.1830*	3.1976*	3.1837	3.1774*
	(1.9007)	(1.8995)	(1.9253)	(1.9007)
Other controls	Yes	Yes	Yes	Yes
R-square	0.0227	0.0232	0.0212	0.0226
F-value	10.49***	10.91***	9.57***	10.44***
N	5560	5560	5560	5560
(B) Education & Province				
Calories, Infancy	0.7592***			
	(0.1595)			
Calories, Adolescence	0.1187			
	(0.0822)			
Protein, Infancy		3.0234***		
		(0.7187)		
Protein, Adolescence		0.4278		
		(0.3591)		
Fat, Infancy			7.8572*	
Fat, Adolescence			1.7740	
			(1.4385)	
Carbohydrate, Infancy				0.3570***
				(0.0729)
Carbohydrate, Adolescence				0.0535
				(0.0370)
Education	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes
Province dummy	Yes	Yes	Yes	Yes
R-square	0.0227	0.0282	0.0240	0.0292
F-value	10.49***	10.04***	8.61***	10.48***
N	5560	5560	5560	5560

We examined robustness of the results, by including additional controls to equation (1), namely, own education and province fixed effect (Table 3.3). Adding education variables does not change the results much. The magnitudes of the coefficients for food availability in infancy and adolescence only slightly diminished (Panel A of Table 3.3). As anticipated, higher educational attainment is positively related to adult height. Conscripts with college education were nearly 2 centimeters taller than those with primary school education or less (control group). Males who attended middle school and those who entered high school are taller than the control group by 0.8 centimeters and 1.5 centimeters, respectively.

Inclusion of province dummy variables changes the regression results significantly (Panel B of Table 3.3). The effects of nutritional availability in infancy became much larger in magnitude with control for province fixed effect. In contrast, the coefficients of the variables capturing nutrition in adolescence remained little changed in magnitude, and lost statistical significance. It is not entirely evident why inclusion of province dummy variables strengthens the effects of nutritional availability during early childhood. A possible explanation is that potential underestimation of nutritional availability in more urbanized provinces is in part fixed by inclusion of province fixed effect. It should be remembered that the nutrition variables in infancy were created from province-level data. Although the two largest metropolitan cities, Seoul and Busan, were excluded from the rural county sample, the agricultural statistics from other provinces still include nutritional productions from all counties including urban areas. Thus, unlike the food availability in adolescence (that was constructed from county-level data), early-childhood nutrition variables may be subject to potential "urban bias," (referring to the fact that although local nutritional production is low in urban areas, actual food consumption could be high because of imports of nutrients from other regions). We suspect that inclusion of province fixed effect reduced such bias.

Results from Alternative Samples

In the baseline regressions, the sample was limited to the individuals born from 1951 to 1957, excluding early birth cohorts. The purpose of the sample restriction was to include in the analyses nutrition variables in infancy that are available only for the 1951-1957 birth cohorts. It remains to be seen whether nutritional availability affected the heights of early birth cohorts as much as it did to those born after 1950. To seek an answer to this question, we conducted height regressions with two separate samples of the 1946-1950 cohorts and the1951-1957 cohorts. We included in the regressions only nutritional availability in adolescence that are available for the entire birth cohorts.

〈Table 4.4〉 Local Nutritional Availability in Adolescence and Height Comparison of the Results from the 1946-1957 Cohorts and the 1951-1957 Cohorts in Rural Counties

Variable	(1)	(2)	(3)	(4)
(A) 1946-1951 Cohorts				
Calories, Adolescence	0.2390***			
	(0.0455)			
Protein, Adolescence		1.0066***		
		(0.1892)		
Fat, Adolescence			3.2564***	
			(0.8288)	
Carbohydrate, Adolescence				0.1078***
				(0.0206)
R-square	0.0092	0.0095	0.0068	0.0090
F-value	6.31***	6.75***	6.21***	6.31***
N	7850	7850	7850	7850
(B) 1951-1957 Cohorts				

Variable	(1)	(2)	(3)	(4)
Calories, Adolescence	0.1610***			
	(0.0508)			
Protein, Adolescence		0.6570***		
		(0.2024)		
Fat, Adolescence			1.8159**	
			(0.8880)	
Carbohydrate, Adolescence				0.0725***
				(0.0231)
R-square	0.0064	0.0065	0.0050	0.0063
F-value	3.20***	3.34***	2.95***	3.19***
N	5560	5560	5560	5560

The results are reported in Table 5.4. All nutritional availability variables are positive and significant for the two samples of early and late birth cohorts. Two features stand out from comparisons between the results from the two samples with different birth cohorts (Panels A and B of Table 4.4) and between the results from different specifications (regressions with and without including nutrition variables in infancy: Table 4.1 and Panel B of Table 4.4). First, the heights of early birth cohorts were more strongly affected by local nutritional availability in adolescence than were the heights of the cohorts born after 1950. The coefficients for nutrition variables estimated from the sample of 1946-1950 cohorts (Panel A) are 50% to 70% larger than those obtained from the sample of 1951-1957 cohorts (Panel B). This result suggests that marginal benefits of improved nutrition were probably greater for early birth cohorts who were shorter and more severely undernourished than late birth cohorts.

Second, the effects of nutrition in adolescence estimated with and without variables on nutrition in infancy (Table 4.1 and Panel B of Table 4.4) are remarkably similar, although the magnitudes of the coefficients for calories, protein, and fat slightly increased; and the coefficient for carbohydrate slightly diminished. In other words, adding early-childhood nutrition to regressions does not change the estimated effects of nutrition in adolescence. Similarly, if variables indicating nutritional availability in adolescence were omitted from the baseline regressions (Table 4.1), the estimated effects of food availability in infancy only slightly increased in magnitude (results not reported here). This result suggests that nutritional status in infancy and in adolescence perhaps independently affected adult height.

〈Table 4.5〉 Local Nutritional Availability and Height: Farmer's Sons in Rural Counties

Variable	(1)	(2)	(3)	(4)
Intercept	164.9700***	164.6855***	166.0229***	165.0222***
	(0.5722)	(0.5871)	(0.4066)	(0.5718)
Local Nutritional availability				
Calories, Infancy	0.4594***			
	(0.1435)			
Calories, Adolescence	0.0913			
	(0.0677)			
Protein, Infancy		2.2225***		
		(0.6180)		
Protein, Adolescence		0.4459*		
		(0.2523)		
Fat, Infancy			5.8666	
			(3.6528)	
Fat, Adolescence			0.9934	
			(1.1792)	
Carbohydrate, Infancy				0.2106***
				(0.0663)
Carbohydrate, Adolescence				0.0398
				(0.0311)
Local environment				
Population density	-0.0053	-0.0037	-0.0003	-0.0060
	(0.0159)	(0.0152)	(0.0162)	(0.0160)
Nonfarm population share	-0.0065	-0.0099	-0.0134	-0.0056
	(0.0110)	(0.0107)	(0.0098)	(0.0110)
Season of Birth				
First quarter	NI	NI	NI	NI
Second quarter	0.3729	0.3760	0.3769	0.3730
	(0.2341)	(0.2351)	(0.2360)	(0.2339)
Third quarter	-0.0474	-0.0255	-0.0126	-0.0511
	(0.2462)	(0.2466)	(0.2497)	(0.2462)
Fourth quarter	-0.1352	-0.1284	-0.1357	-0.1368
	(0.2800)	(0.2797)	(0.2782)	(0.2801)
Family size				
1 to 3	0.1311	0.1429	0.1587	0.1289
	(0.6084)	(0.6076)	(0.6115)	(0.6091)
4 to 6	NI	NI	NI	NI
7 or more	0.2335	0.2213	0.2344	0.2372
	(0.2014)	(0.2015)	(0.2014)	(0.2015)
R-square	0.0077	0.0083	0.0040	0.0075
F-value	5.29***	5.87***	2.49**	5.19***
N	2784	2784	2784	2784

If we are to select a subsample of conscripts whose nutritional status in growing ages were most strongly influenced by our measure of local nutritional availability (calories or size of nutrients per farm household adult male equivalent), it should be men from farm households. We cannot determine whether a person lived in a farm household or not in childhood. Thus, we had to select a sample of individuals from rural counties whose father was farmer at the time of conscription. This selection process is subject to measurement errors, because of possible occupational changes and retirement of father. A certain proportion of the conscripts who lived in farm households in childhood could be excluded from this subsample if their father had left farming or retired. However, it is likely that the majority of farmers' sons actually lived in farm households given the low probability that people in the 1950s and 1960s transferred from nonfarm occupations to farming. This subsample consists of 2,784 men, about half the size of our baseline sample.

Table 4.5 presents the results from using the subsample of farmers' sons. Nutritional availability in infancy exerts much stronger effects on adult height, compared to the baseline results (Table 4.1): the magnitudes of the effects increased by 70% (protein) to three times (fat). In contrast, the effects of nutrition in adolescence modestly diminished in magnitude and became statistically insignificant. These changes are qualitatively similar to the changes made by addition of province fixed effect to baseline regressions (Panel B of Table 4.3). Sons of non-farmers were more likely come from urbanized places. Therefore, excluding these conscripts would reduce the influences of including urban counties in the estimation of food productions, which is similar to the result of including province fixed effect.

〈Table 4.6〉 Local Nutritional Availability and Height: All Persons with Information on Local Nutritional Productions

Variable	(1)	(2)	(3)	(4)
Intercept	165.2001***	165.7656***	166.4914***	165.2691***
	(0.3690)	(0.2868)	(0.1767)	(0.3640)
Local Nutritional availability				
Calories, Infancy	0.3570***			
	(0.0923)			
Calories, Adolescence	0.0760*			
	(0.0438)			
Protein, Infancy		1.0424***		
		(0.3138)		
Protein, Adolescence		0.1181		
		(0.1057)		
Fat, Infancy			1.3876*	
			(0.7584)	
Fat, Adolescence			-0.0902	
			(0.1810)	
Carbohydrate, Infancy				0.1405***
				(0.0423)
Carbohydrate, Adolescence				0.0427**
				(0.0202)
Local environment				

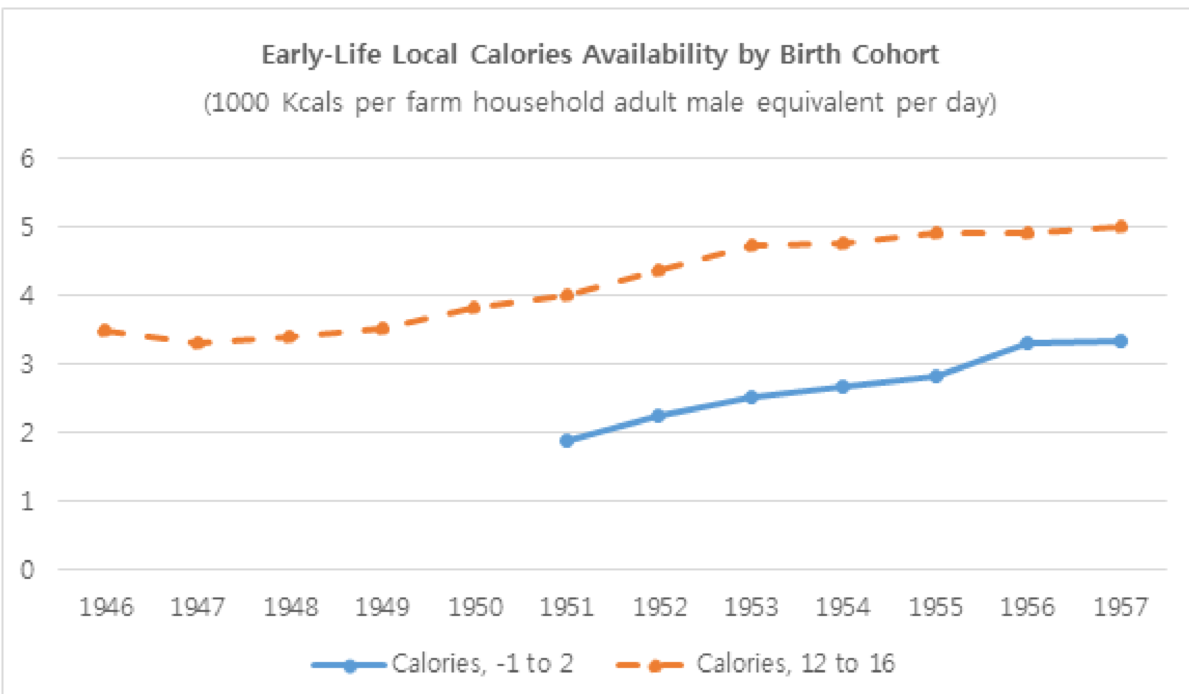
Variable	(1)	(2)	(3)	(4)
Population density	0.0025	-0.0022	-0.0008	0.0040
	(0.0023)	(0.0024)	(0.0033)	(0.0027)
Nonfarm population share	0.0021	0.0007	0.0015	0.0031
	(0.0029)	(0.0029)	(0.0027)	(0.0029)
Season of Birth				
First quarter	NI	NI	NI	NI
Second quarter	0.3287**	0.3237**	0.3160**	0.3271**
	(0.1430)	(0.1427)	(0.1420)	(0.1428)
Third quarter	-0.0480	-0.0380	-0.0409	-0.0523
	(0.1370)	(0.1370)	(0.1374)	(0.1368)
Fourth quarter	-0.1783	-0.1706	-0.1760	-0.1819
	(0.1612)	(0.1610)	(0.1616)	(0.1613)
Family size				
1 to 3	0.2061	0.1959	0.1734	0.1980
	(0.2803)	(0.2898)	(0.2878)	(0.2801)
4 to 6	NI	NI	NI	NI
7 or more	0.0446	0.0552	0.0564	0.0423
	(0.1196)	(0.1198)	(0.1202)	(0.1197)
Father's occupation				
Professional	1.3423*	1.3604*	1.3496*	1.3340*
	(0.7285)	(0.7360)	(0.7456)	(0.7301)
Clerical	1.1388***	1.1564***	1.1539***	1.1362***
	(0.4184)	(0.4200)	(0.4192)	(0.4179)
Service	-0.5282	-0.4891	-0.4662	-0.5297
	(0.8523)	(0.8617)	(0.8616)	(0.8502)
Farming	NI	NI	NI	NI
Manual	-0.4418	-0.4245	-0.4325	-0.4443
	(0.3311)	(0.3306)	(0.3301)	(0.3307)
No job	-0.1781	-0.1847	-0.2134	-0.1889
	(0.1510)	(0.1487)	(0.1496)	(0.1510)
Father absent	-0.1041	-0.1166	-0.1326	-0.1084
	(0.1776)	(0.1761)	(0.1764)	(0.1779)
R-square	0.0074	0.0067	0.0050	0.0069
F-value	4.53***	3.80***	2.93***	4.42***
N	7867	7867	7867	7867

Finally, we extended our sample to include conscripts from urban areas in which nutritional production per farm population exceeded a minimum threshold: calories per farm household adult male equivalent in the county (district/city) of residence at age 14 were greater than 1000Kcal. The extended sample of 7,867 conscripts additionally include men from urban districts with sizable number of farm households specialized in agricultural productions. This sample accounts for about 90% of the entire sample of the 1951-1957 birth cohorts for whom height and county of residence are available. That is, a relatively small fraction of the entire sample representing highly-urbanized areas were excluded from our analysis provided below.

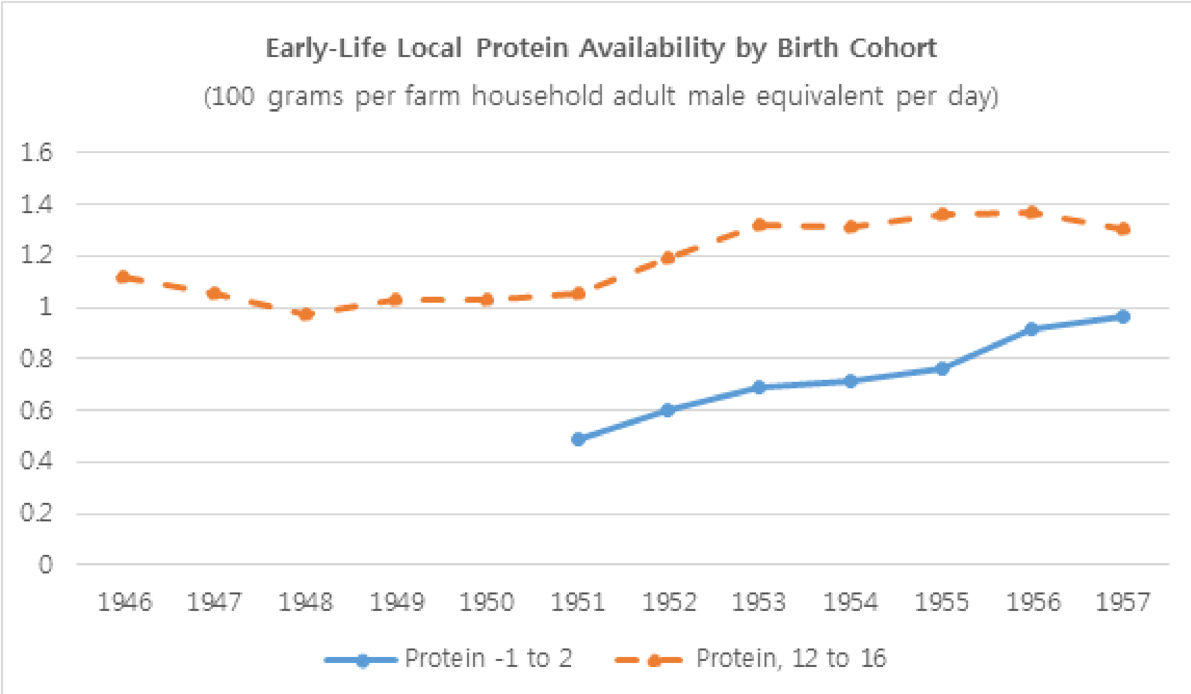
Table 4.6 reports the results from using the extended sample. In general, the estimated effects of nutrition variables are similar to the results from the baseline regressions performed based on the rural county sample (Table 4.1). Major exceptions are: the effects of protein and fat in adolescence became weaker in terms of both magnitude and statistical significance. This result suggest that the significant positive effects of nutritional availability (particularly during early childhood) on height remain visible for a large proportion of the entire population.

Improved Nutrition and Increase in Adult Height

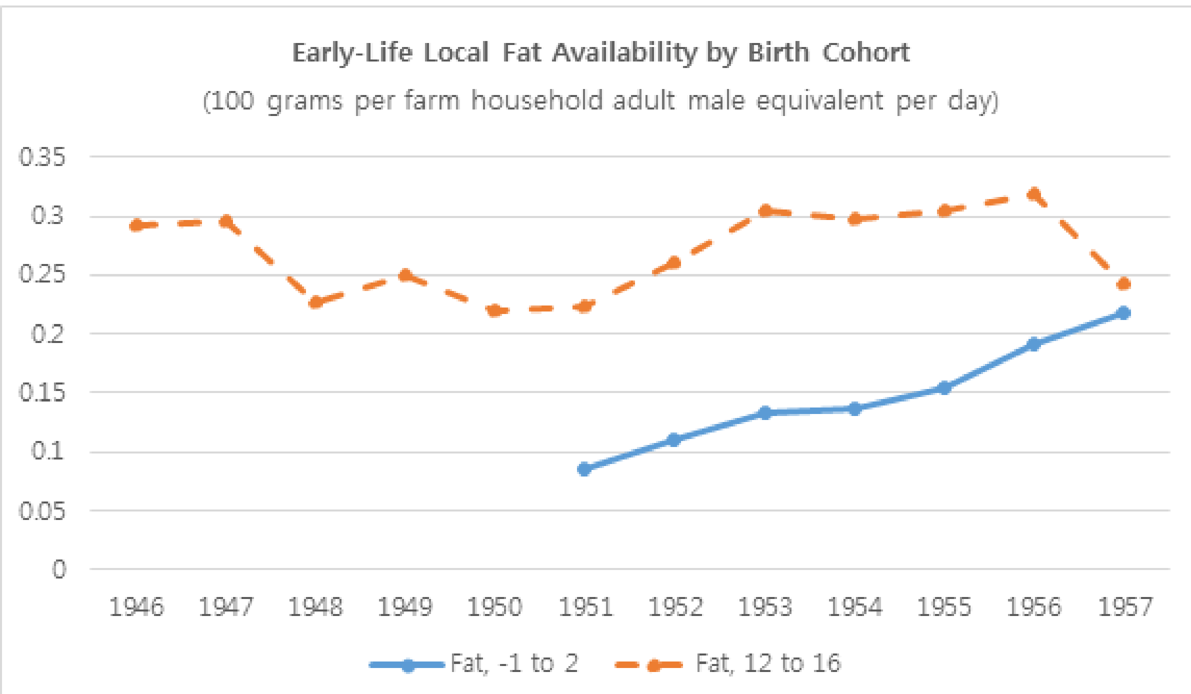
The regression results given above suggest that local nutritional availability in growth periods was an important determinant of adult height. The average height of Korean conscripts rapidly increased between the cohort born in 1951 and those born in 1957. During the six years, about 2 centimeters were gained. As can be expected from the process of recovery from the aftermath of the Korean War, and rise in income and agricultural productivity that followed, the quality and quantity of diet in childhood and adolescence likely improved across birth cohorts. Our final question is how much improved nutrition contributed to the rapid increase in height of the birth cohorts under investigation.



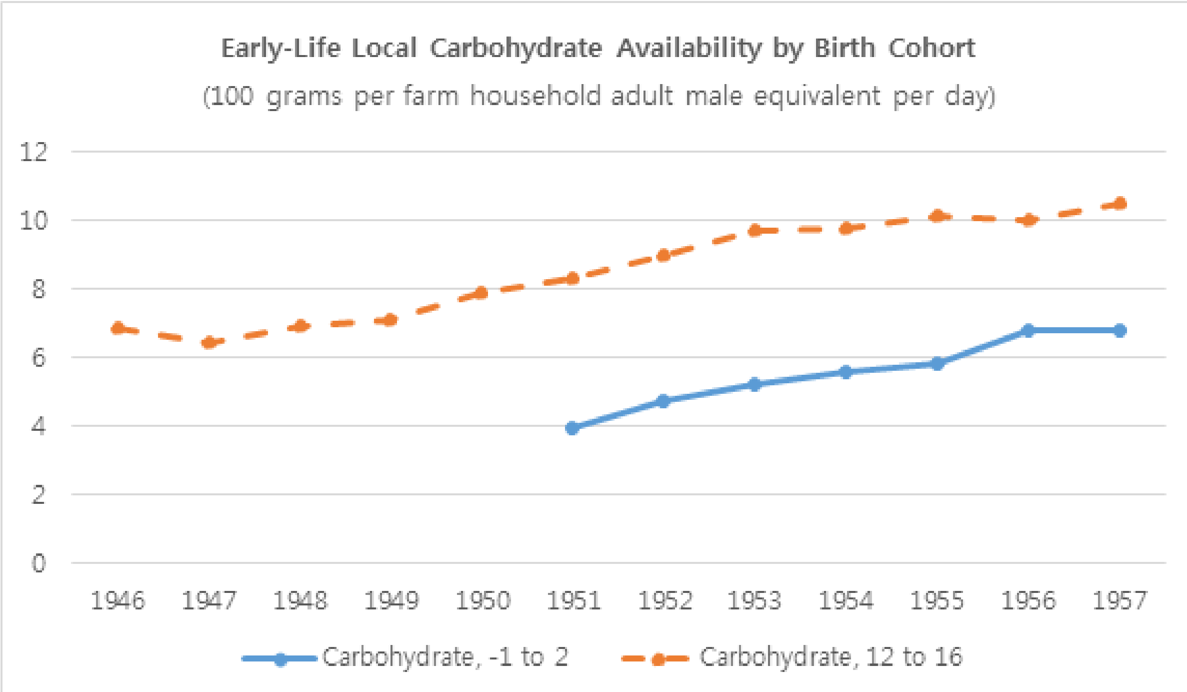
〈Figure 4.1〉 Early-Life Local Calories Availability by Birth Cohort



〈Figure 4.2〉 Early-Life Local Protein Availability by Birth Cohort



〈Figure 4.3〉 Early-Life Local Fat Availability by Birth Cohort



〈Figure 4.4〉 Early-Life Local Carbohydrate Availability by Birth Cohort

Figures 4.1 to 4.4 visually present how nutritional availability in early childhood and in adolescence changed across different birth cohorts. Productions of calories and the three major nutrients in both infancy and adolescence substantially increased between the 1951 birth cohort and the 1957 birth cohort. Food availability during early childhood, especially the productions of protein and fat, increased more rapidly than nutritional availability during adolescence. The provisions of protein and fat in early childhood more than doubled between the 1951 cohort and 1957 cohort. We were unable to estimate nutritional availability in infancy for men who were born prior to 1951. Productions of calories and major nutrients in adolescence stagnated or increased only slowly from the 1946 cohort to the 1951 cohort. Thus, the cohort trends of nutritional availability and of adult height from 1946 to 1957 seem to match well.

〈Table 4.7〉 Height Change Predicted by Increase in Nutritional Production

	(1) Calories (1000Kcals)		(2) Protein (100g)		(3) Fat (100g)		(4) Carbohydrate (100g)	
	Age -1 to 2	Age 12-16	Age -1 to 2	Age 12-16	Age -1 to 2	Age 12-16	Age -1 to 2	Age 12-16
A. 1951 cohort	1.876	4.011	0.491	1.057	0.085	0.223	3.958	8.296
B. 1952 cohort	2.260	4.361	0.603	1.189	0.111	0.261	4.731	8.973
C. 1953 cohort	2.511	4.747	0.686	1.318	0.133	0.305	5.222	9.698
D. 1954 cohort	2.678	4.773	0.711	1.311	0.136	0.297	5.576	9.792
E. 1955 cohort	2.818	4.929	0.766	1.363	0.154	0.304	5.823	10.121
F. 1956 cohort	3.304	4.910	0.919	1.372	0.191	0.318	6.793	10.042
G. 1957 cohort	3.341	5.002	0.968	1.299	0.218	0.242	6.777	10.521
H. Change (G-A)	1.465	0.991	0.477	0.242	0.133	0.019	2.819	2.225
I. Regression Coefficient	0.357	0.076	1.042	0.118+	1.388	-0.090+	0.141	0.043
J. Predicted height change (H×I)	0.523	0.074	0.497	0	0.185	0	0.397	0.096

Note. The sample includes 11508 persons born between 1951 and 1957 with information on height and nutritional availability in both infancy (age -1 to 2) and in early adolescence (age 12 to 16). The coefficients for variables regarding local nutritional production are from the regressions conducted based on the same sample (Table 4.3). The mean height of this sample is 165.48cm for 1951 and 167.42cm for 1957.

We conducted an exercise to obtain a back-of-envelop estimate as to how improved nutrition in growing ages contributed to the increase in heights of conscripts. Using the largest possible sample for whom nutritional availability in infancy and adolescence is provided (a sample of 7,867 men used in the regressions reported in Table 4.6), we first computed the measures of nutritional availability for each cohort from 1951 to 1957 (Panels A to G in Table 4.7), and the magnitude of increase in each measure (Panel H in Table 4.7). For example, calories available in infancy increased by 1,465 Kcals between 1951 cohort and 1957 cohort. We then multiplied the size of the increase by the estimated regression coefficient for the corresponding nutrition variable to calculate the magnitude of height change predicted by increase in the measure of nutrition. For the computation, the regression results from using the same sample of 7,867 conscripts (Table 4.6) were used.

The result of the exercise suggests that improved nutrition in growth periods, especially in early childhood, may have substantially contributed to the increase in height from 1951 to 1957. First, increased calorie availability would have increased adult height by about 0.6 centimeters. A lion's share (0.52 centimeters) of this contribution is attributable to the increased calories in infancy. Likewise, changes in availability of protein, fat, and carbohydrate would have resulted in a growth of adult height by 0.5 centimeters, 0.19 centimeters, and 0.49 centimeters, respectively. Because the four measures of nutritional availability are correlated to one another, it is difficult to estimate the combined effect of calories and various nutrients. If only the effect of calories is concerned, nutritional improvement accounts for 30% of the increase in average height between 1951 cohort and 1957 cohort (about 2 centimeters). If we assume that the three major nutrients (protein, fat, and carbohydrate) independently contributed to height change, their joint effect would be an increase in height by 1.1 centimeters. Applying larger estimates of the effect of nutritional availability from using alternative samples (e.g. the sample of farmers' sons: Table 4.5) or specifications (e.g. adding province fixed effect: Panel (B) of Table 4.3) would make the contribution of nutritional improvement even more important.

Conclusion

It is generally accepted that the rapid economic growth in South Korea during the second half of the twentieth century greatly improved the standards of living of the country's population. However, it is not fully understood how the living conditions in South Korea changed over time, and what are the major factors that produced the changes. For instance, there is still much to be learned about how the process of improvements differed by socioeconomic characteristics, and about how the experiences of each birth cohort differed with each other. We do not fully understand how particular economic or social changes affected the wellbeing of the population, either. Rigorous research on these issues is often seriously hampered by shortage of appropriate data, especially for the periods prior to the 1970.

In our previous study (Lee 2016), supported by the 2015 Cliometric Study Program of the KDI School of Public Policy and Management, we investigated how biological indices of standards of living, such as height, weight, and body-mass-index (BMI, hereafter) changed across birth cohorts born between 1946 and 1957, based on a newly collected sample of military records for more than 18,000 conscripts. We found that the mean height at conscription slightly declined from the 1946 cohort to the1951 birth cohorts before it rapidly increased across cohorts. The mean height increased by more than two centimeters in just 6 years between 1951 and 1957. We also found considerably large variations across provinces in the patterns of changes in anthropometric measures as well as the levels of the measures. In the previous study, however, we were unable to determine what factors produced the changes in anthropometric measures across different birth cohorts and across different regions.

In the present study, we investigated how nutritional availability in two crucial periods for human growth, namely, early childhood (from conception to age 2) and adolescence (from age 12 to age 16), affected the heights of Korean conscripts born from 1946 to 1957. For the purpose, we constructed province- and county-level data on agricultural productions, and matched the dataset with the sample of conscripts using the information on place of residence. We also explored how much improved nutrition during infancy and adolescence contributed to the increase in heights between the 1951 cohort and the 1957 cohort.

We used the amounts of calories and three major nutrients (protein, fat, and carbohydrate) per farm household adult equivalent in a given province or county as our primary measures of local nutritional availability. In addition to nutrition variables, we considered local environmental conditions indicated by population density and nonfarm population share as well as personal and family characteristics such as season of birth, family size, and father’s occupation. We selected several different samples for whom the effects of our measure local nutritional availability on heights might differ with one another. These samples include: men from counties with information on nutritional availability, men from rural counties (baseline sample), and farmers’ sons living in rural counties.

The regression results suggest that variables on local nutritional availability are generally positive and statistically significant. According to the results from the rural county sample, a person who spent infancy in a province that produced calories per farm population one standard deviation above the mean would have been about 0.2 centimeters taller at the time of conscription, if other things equal. A one standard deviation increase in protein or carbohydrate in infancy would result in an increase in height by a similar magnitude. The estimated coefficients for nutritional availability variables in adolescence are generally smaller in magnitude and statistically less significant.

A major drawback of our analyses is that the true birth place of a conscript is unknown. To reduce potential measurement errors arising from geographic mobility between birth and conscription, we used a subsample of men from rural counties whose province of residence at the time of conscription is the same as the province of “original family place (Bonjeok).” If a conscript’s current address and Bonjeok are identical, it is likely that he was born in the current province of residence. About 79 percent of the full sample and 91 percent of the rural county sample reported the same current and

Bonjeok province, which implies that prior geographic mobility of the conscripts in the sample was probably low. The regressions conducted based on the subsample reveal larger effects of nutritional availability on heights, compared to the baseline results.

We performed height regressions with various samples alternative specifications. Adding the conscripts' own education does not noticeably change the results. By contrast, inclusion of province fixed effect greatly increases the size of the effects of nutritional availability in early childhood. The effects of nutrition availability variables in adolescence are stronger for the 1946-1950 birth cohorts than those for the 1951-1957 birth cohorts. If the sample is limited to farmers' sons from rural areas, the estimated coefficients for nutrition variables become larger. If the sample is extended to include men from urban counties with minimum agricultural productions, the baseline results remain little changed.

We finally explored how much improved nutrition contributed to the increase in height between the 1951 and 1957 birth cohorts. The cohort trends of nutritional availability and height match well, which is consistent with the hypothesis that early-life nutrition mattered for growth of stature for the birth cohorts under investigation. For estimating the contribution of improved nutrition to the increase in height, we computed the change in height predicted by change in nutrition using height regression results and estimated change in each nutritional availability variable between 1951 and 1957. The result suggests that improved nutrition in early childhood and adolescence accounts for 30 percent to 50 percent of the increase in adult height that was gained from the 1951 and 1957 birth cohorts. Increased nutritional availability during early childhood explains a lion's share of the contribution.

The results of this study strongly suggest that nutrition was an important determining factor of biological standards of living indicated by adult height. In particular, provisions of calories and protein were strongly associated with larger stature. Food availability during early childhood was more critical for human growth than nutrition in adolescence. This result is consistent with the consensus that catch-up growth in adolescence is insufficient to fully make up for deficiencies in early childhood. Although our estimate is highly preliminary and subject to errors, it is likely that improvements in the quantity and quality of nutritional intakes that were made possible by increased incomes and enhanced agricultural productivity significantly contributed to the rise of biological standard of living indicated by changes in anthropometric measures.

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