THE INTERACTION OF COMMUNITY FACTORS AND INDIVIDUAL CHARACTERISTICS ON CHILD HEIGHT IN CHINA

Feng Zhao, Ph.D, MD, MPH
The World Bank Group & Johns Hopkins University
9056 Waltham Woods Rd.
Parkville, MD 21234
Fzhao@jhsph.edu

David Bishai, Ph.D, MD, MPH
Johns Hopkins University
Department of Population and Family Health Sciences
615 North Wolfe Street
Baltimore MD 21205
dbishai@jhsph.edu

INTRODUCTION

The issue of complementarity and substitutability between community factors and individual characteristics has long been a concern in the field of child health, especially in developing countries. It addresses important research and policy questions. For example, can advantageous individual characteristics mitigate effects from an adverse shock or harmful environment? Which individual characteristics—including occupation, wealth (income) and education—play bigger roles to interact with community factors? Why do the community factors act differently for different socioeconomic groups? The answers to these questions play important roles in setting up effective health interventions to improve child health.

Although studies on this subject are scarce, some have provided some insights about how the community factors and individual characteristics interact. But there is still some debate regarding the direction of the interaction. Rosenzweig and Schultz (Rosenzweig and Schultz 1982) found that maternal education can *substitute* for the effect of public health facilities on child mortality in Colombia's urban settings concluding that the positive effect of community factors (mainly municipality health services) on child survival are mitigated after controlling for mothers' average education level. In their study of child survival in West Africa, Benefo and Schultz (Benefo and Schultz 1994) revealed a *complementary* effect of maternal education on community water supply and proximity to a health facility in Ghana, and on provision of sanitation in Cote d'Ioire. Strauss (Strauss 1990) shows there is *no significant interaction* between maternal education and community variables in rural Cote d'Ivoire although they both are important determinants to child health individually. Later studies became more

sophisticated in selecting community variables and some have shown different community variables may act differently. For example, Thomas and his colleagues (Thomas and Strauss 1990) report a substitutive interaction between health services and maternal education and a complementary effect of sewage services on maternal education in Brazil. In their study in Philippines, Barrera et al. (Barrera 1990) found that environmental cleanliness and water connection served as substitutes while access to health facilities and toilet facility functions as complements to maternal education. Studying the impact of health and market prices on both child mortality and child anthropometry indicators, Lavy et. al. (Lavy et al. 1996)concluded that more nurses and larger health facilities may help rural children in Ghana but they have no significant effect on urban kids. One interesting finding in Sastry's study in Brazil (Sastry 1996a) is that the direction of interactions between community variables and maternal education varies in different regions. For example, sanitation network connections appear to be a substitute for maternal education in one region but serves as a complement in another region of Brazil.

Most research on this topic has been subject to many weaknesses. First, the community variables were very broadly defined, especially in the early papers. Distance to a health facility often is the only community variable. Although later papers added more indicators regarding health services such as size of the facilities, type of services, and even some quality aspects of health services, they tend to focus only on health services in a community; other important community factors such as economic development (infrastructure, trade activities), culture (norms), and political environment were often ignored. This raises the question of whether the interactive effects of

community health services with maternal education identified in these studies may be confounded by other community factors. Second, the majority of the studies focus on maternal education at the individual/household levels. Data on household characteristics other than maternal education is extremely limited. Although some efforts have been made to investigate other variables such as urban/rural (Lavy et al. 1996) and income (Sastry 1996), the knowledge gap remains large. Third, to study child health, researchers usually focus on child mortality as an outcome variable; Child malnutrition, which can be measured by anthropometric indicators such as child height and child weight, is underused. Child malnutrition is not only an important indicator of child mortality but also can sensitively reflect changes in environment (dietary intake, presence of disease, etc.) and therefore is accepted as a good indicator of overall child health (WHO Expert Committee on Physical Status 1995). Except for Lavy's paper (1996), all the other studies cited above use child mortality/survival as the sole outcome variable. Finally, the disagreement on the direction of the interaction in different countries suggests that the direction of the interaction may differ across regions and cultures. Therefore, research in other parts of the world can contribute to the knowledge base of this important area. As Sastry (1996) stated, "knowledge about the consistency of findings across countries, over different periods, and for different indicators of child health" (p.212) is much needed.

The limited, mixed and somewhat ambiguous empirical findings have motivated researchers to investigate the mechanism and pathways of the effect of community variables on child health. The role of community factors in determining child health has been well recognized in theory. The famous Mosley-Chen framework (Mosley and Chen 1984) for child survival in developing countries and the economic theory of household

behavior (Becker 1965) and household production of health (Grossman 1972) all emphasize the significant and important contributions of environmental (community) factors to child health. Schultz (Schultz 1984a) explicitly points out three sets of distal determinants of child health: (a) individual endowment variables including economic endowments (education, wealth etc.) and biological endowment; (b) community or regional variables; and (c) unobserved preferences or individual/family goals. He further gave recommendations regarding the specification and measurement of these community variables, suggesting that researchers should consider the following measures for community factors: The first one is market price variations, which can be proxied by access or availability of public and private services or local wage rates. The second measure should be related to the productive environment, including those factors which may alter the household production process of child health such as a local climate conducive to malaria and some political or administrative factors related to household demand-production behavior of child health. The last category is the health program, delivering necessary health inputs to child health at the community level. Based on Schultz (1984), community factors may play three distinct roles in affecting child health:

> "They may reduce the price of the health inputs, directly through subsidization of the goods or services, or indirectly by increasing access to them, thereby reducing the time or travel costs to evaluate and use the services; they may provide information on how to produce health more efficiently. This might include information on new inputs or on efficient practices with traditional inputs such as breastfeeding; they may alter the health environment, without directly affecting other opportunities available to people such as control of malaria and eradication of smallpox" (p. 222).

Parallel with Schultz but from a slightly different angle, Penders et. al. (Penders et al. 2000b), Lavy et. al. (1996) and Sastry (1996) think besides health care services, measures of community infrastructure and political and cultural norms should be taken into account since they represent important dimensions of a community related to child health. More importantly, previous studies have begun to recognize that these community characteristics may operate through different pathways or mechanisms to interact with individual variables. In Penders and his colleagues' study (2000), infrastructure and agriculture commercialization in a community, as a proxy of development level, tend not only to raise the income level but also diversify income sources. This would make households less dependent on farming income and less vulnerable to seasonal insecurity. As a result, more money might be spent on food, especially those expensive foods like meat. Also, working opportunities other than agriculture would reduce women's agriculture participation, therefore increase the time for care giving. Therefore, living in a well developed community would benefit the disadvantaged household (less educated, lower income, and farmers) more, and function as a substitute to those unfavorable individual characteristics. Sastry (1996) suggested that maternal education substitutes for services that *provide* knowledge, skills, and an environment conducive to raising healthy children, and that it is likely to complement local services that *require* knowledge and skills. For example, more specialized services will complement education and income whereas basic and nonspecialized services will play a substitution role. These theoretical efforts have provided some insight into how community factors and individual characteristics interact, and help guide the specification of community variables.

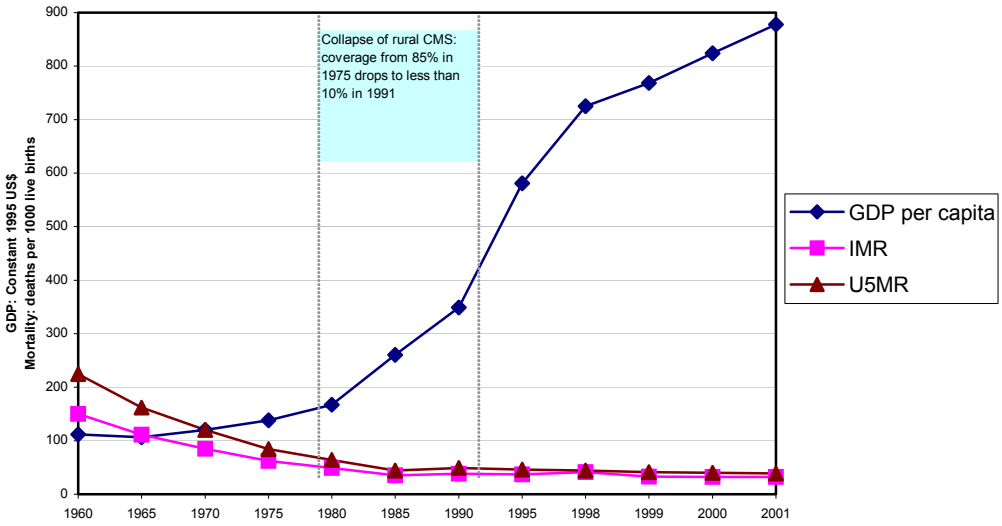
While the research in this field is heading to a promising direction, significant gaps exist and need to be addressed. This study intends to contribute to the knowledge base in the following way. First, we try to systematically and comprehensively specify the community factors to include not only measures of infrastructure, market activities, water and sanitation conditions and health care services but also some political and policy features related to child health. Second, we will not only use education but also income and primary education (farmers vs. nonfarmers) to interact with community factors. Third, to make up for the scarcity of child nutrition status studies in this topic, we will use child stunting to measure child health. Finally, this study uses data from China, where, to the best of my knowledge, such a study has never been undertaken before.

CHILD HEALTH STATUS IN CHINA

From the 1960s to the 1980s, China made remarkable progress in improving child health, and was regarded, along with Sri Lanka and Costa Rica, as a model of "good health at low cost"(Halstead et al. 1985). In this period, China's average annual GDP per capital was well below $200 (1995 US dollars) with very modest gains over a period of 20 years. But despite the low level of economic development, the infant mortality rate (IMR) and the under-five mortality rate (U5MR) plummeted from 150 and 250 per 1,000 live births in 1960 to 35 and 44 in 1985 respectively, one of the few largest declines in public health history (Box Figure1) (UNICEF 2003; World Bank 2003c). More impressively, China achieved this at a contained health care cost of health care at just over 3 percent of its total GDP (World Bank 2003c).

The success has been attributed to the following factors. One, the government's political and financial commitment to providing basic preventive and curative health care to its population at a low cost. Two, an effective risk-pooling health financing system for both rural and urban populations to ensure access to basic health care services. The risk-pooling financing system comprises with two components: a community-based collective financing system in rural regions—the rural Cooperative Medical System (CMS), and two urban insurance systems—the Government Employees Health Insurance System (GIS) and the Labor Health Insurance System (LIS). By 1975, almost 90 percent of China's population was covered by either CMS or the urban insurance plans (World Bank 1996). Three, a well-functioning three-tier primary health care delivery system (county-township-village) that provides basic professional periodic and continuous health services for its rural residents, who comprise about 80 percent of China's total population. The integration of township hospitals and bare-foot village doctors especially facilitated the operation of public health programs such as immunization and put basic curative care within reach of the majority of the rural population.

Figure 1: Trends of GDP per capital and Child Mortality: China 1960-2001

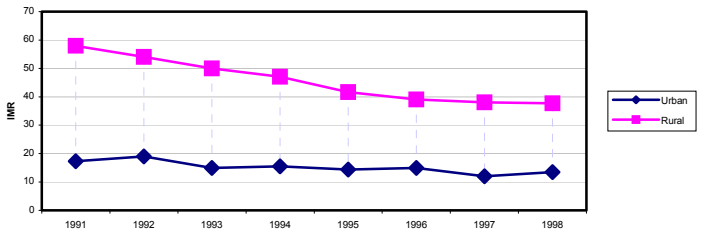


Sources: Unicef data for child mortality; World Bank data for GDP per capita

Beginning in 1978, economic reform took place in China, with a shift from a centrally planned economy to a market-oriented economy.. The economic reform greatly stimulated economic development, and GDP per capita grew rapidly to $878 (1995 US$) in 2001, about 9 times of that in the 1970s (Figure 1) (World Bank 2003c). However, economic growth has brought about mixed consequences on health status. In the rural areas, the privatization transition from the collective ideology and commune system to household responsibility weakened the fundamental structure of the CMS, resulting in a collapse of the once successful system. The coverage of CMS dropped from 85 percent in 1975 to less than 10 percent in 1991 (Zhang 2001). As a result, child health in China suffered a major setback. After decades of steady decline, the child mortality rates have remained stagnant since 1985, even showing slight increases in some periods (Figure 1).

Since the economic reform, inequality has become a growing concern in almost all the aspects of Chinese society. Child mortality is no exception. For China, of even greater concern than the stagnant child mortality trend at the national average, are the gaps in child mortality within China's population. Some sub-populations are especially vulnerable. Substantial child mortality differentials appeared after the 1978 reform, particularly between urban and rural populations. Rural children suffer significantly higher mortality rates than urban children. In 1991, the child mortality rates in rural regions were about six times higher than those in urban areas (Ministry of Health 2003). Although the gap shrank from 1991 to 1995, it remains large. Since1995, the urban-rural differential has stabilized with the rural mortality rate three times higher than the urban rate (Figure 5). In big cities such as Beijing and Shanghai, the infant mortality rate has reached 5.05 per 1,000 live births in 2000 (Li 2001), equivalent to the level of the OECD countries (3.9/1,000 in Japan, 7.2/1,000 in U.S., 4.3/1,000 in France in the same year (UNICEF 2003)), while the poorest rural areas suffer child mortality rates at the same level of those in the Sub-Saharan African countries. Recent UN reports indicate increases in child mortality in some poor rural areas (UNICEF 2003).

Figure 2: Rural/urban Inequality in China Mortality in China



Source: Li, C.M. (2001)

Most of the studies focus on child mortality, thus our knowledge on the effects of economic reform on child growth such as child height is extremely limited. Among the few publications on this topic, Shen and his colleagues (Shen et al. 1996) use data from five large cross-sectional surveys conducted 1975 and 1992 to examine the trends in child height in urban and rural areas. They reported that, although the average height increased during the economic reform, the difference in height between rural and urban children also grew larger. In a 1990 survey 38 percent of rural children had stunting of growth, as compared with 10 percent of urban children.

MODEL

Becker's pioneering economic theory of family (Becker 1965) and Grossman's work (Grossman 1972) on the demand and production of health have provided valuable guidance to the model of child health. Households maximize their utility from a healthy

child by consuming commodities and services, allocating their time and resource purposely, and best utilizing their economic (education and income) endowment and biological endowment. The utility-maximizing process is constrained by both the health production function and a total budget constraint (including time constraint). To integrate the technological production relationship of child health with its biomedical health inputs with a behavioral demand for child health function, economists usually derive a reduced-form demand function for child health from the utility maximization process and its constraints (Lavy et al. 1996; Schultz 1984a; Thomas and Strauss 1990). The demand for child health depends on exogenous variables at the individual, household and community levels. In the traditional sense of a demand equation, these exogenous variables represent or serve as proxies of price, income or taste shifters. In this study, a reduced-form equation for demand for child health can be written as follows (DaVanzo and Gertler 1990a):

$$H_{ij} = h(X_{ihj}, X_j, \varepsilon_{ij}) \qquad (1)$$

Where X_{ihj} is a vector of individual and household variables including education, wealth (income), primary occupation, age, sex, ethnicity etc. The first three variables will be used to study potential interaction with community factors. X_j represents a vector of community characteristics such as infrastructure, market trading activities, water and sanitation conditions, health care services and policy and political factors. ε_{ij} is a random error term reflecting heterogeneity in individual taste, health endowment and unobserved factors.

Community factors can affect child health directly and also operate through individual/household variables; therefore, the first-order derivative of child health on the individual/household variables is a function of the community variables. A simple mathematical expression can be shown as follows:

$$\partial H_{ij} / \partial X_{ihj} = f(\partial X_j , \varepsilon_{ij}) \qquad (2)$$

In Equation (2), community variables X_j have an effect on child health H_{ij} through individual/household variables X_{ihj}. If:

$\partial H_{ij}^2 / (\partial X_{ihj} * \partial X_j) > 0$ the two variables are complements;

$\partial H_{ij}^2 / (\partial X_{ihj} * \partial X_j) < 0$ the two variables are substitutes.

This study examines the interaction of three individual/household variables — education, wealth (income) and primary occupation — with a set of community factors.

Community infrastructure: measured by the presence of shops, theaters, communication services (telegraph, telephone, fax and postal service), daily newspaper, bus stop, train station, road condition, electricity, public bath etc. As a proxy of development level, a better developed community may associate with higher and more diversified incomes and posses more opportunity for non-agricultural jobs, which may lead to a greater expenditures on food and more care-giving time. In addition, better infrastructure may represent more opportunity for information flow regarding how to produce health efficiently, and the information may otherwise only be available to the advantaged households. Therefore, we anticipate that better infrastructure will have a big

impact on the disadvantaged families (less educated, lower income and farmers). A substitutive interaction should be observed.

$$\partial H_{ij}^2 / (\partial X_{ihj} * \partial X_{(\text{infrastructure j})}) < 0$$

Health services: local health service measures can be categorized into two types. one is *access-type* services, and their goal is to improve access to basic health services and information of child caring, disease prevention and healthy behaviors. This type of local health service tend to act as a substitute to individual/household level variables. Another is *efficiency-type* services, which intends to increase benefits from health services and let parents utilize more sophisticated and specialized health services more efficiently. This type of service usually requires a certain level of knowledge and skills to understand and use the services correctly. Therefore, it is more likely to complement individual/household level variables.

$$\partial H_{ij}^2 / (\partial X_{ihj} * \partial X_{(\text{access type service j})}) < 0$$

$$\partial H_{ij}^2 / (\partial X_{ihj} * \partial X_{(\text{efficiency type service j})}) > 0$$

Family planning policy: the effect of the family planning policy can be mixed. Following the argument the child quality-quantity trade off theory (Becker and Tomes 1976), one should assume the family planning policy increases the price of child quantity, and parents would responsively invest more on child quality instead. However, this claim has only been observed in urban and some costal rural areas in China, where

average child height increases while the number of children per household decreases over the last two decades (Shen et al. 1996). In the less developed rural and inland areas, households continue to pursue more than one child especially boys under the family planning policy and in most cases they have to take the fines or other types of penalties to satisfy their fertility goal. This makes their scare household resources even less. A study has pointed out that the households with out-of-plan children tend to be the disadvantaged households (Chu 2001). Therefore, we hypothesize that the family planning policy would have a negative association on child height in the disadvantaged households and a positive association in the advantaged households.

Water and sanitation conditions: better conditions can help reduce the incidence of water-borne illness such as malaria, diarrhea, cholera, which are responsible for 35 percent of all deaths of young children worldwide (Penders et al. 2000a). Analogous to the health service variables, two roles can be defined for water and sanitation conditions: access and efficiency. The direction of the interaction may differ based on which role water and sanitation services play. A substitutive effect will be observed if water and sanitation services are to improve access; otherwise, water and sanitation services complement individual/household variables since women in the advantaged households may filter or boil water before drinking it.

Food market availability were measured by the presence and proximity to a variety of food and living material (fabric and fuel) market in a community to reflect the variation of availability and price of necessities for child nutrition. To take advantage of

the market in order to obtain diverse and balance dietary intake, wealth and knowledge are required to be successful. Given that there are usually no subsidies involved for most disadvantaged families, we expect that children in the wealthier, more educated and non-farmer households may benefit from proximity to markets more. Therefore, a complementary effect should be observed.

$$\partial H_{ij}^2 / (\partial X_{ihj} * \partial X_{(\text{food market } j)}) > 0$$

DATA & METHODS

Data

The dataset used for this analysis is the China Health and Nutrition Survey (CHNS) (Carolina Population Center 2003)conducted jointly by the Carolina Population Center at the University of North Carolina at Chapel Hill and the Institute of Nutrition and Food Hygiene of the Chinese Preventive Medicine. The CHNS was designed to examine the effects of the health, nutrition and family planning policies and programs implemented by national and local governments and to see how the social and economic transformation of Chinese society is affecting the health and nutritional status of its population. The survey covers 9 provinces (Guangxi, Guizhou, Heilongjian, Henan, Hubei, Hunan, Jiangsu, Liaoning, Shandong) that vary substantially in geography, economic development, public resources, and health indicators. A multistage, random cluster process was used to draw the sample surveyed in each of the provinces. As an

open cohort panel survey, the CHNS has conducted in four waves: 1989 (3,795 households and 15,917 individuals), 1991 (3,616 households and 14,778 individuals), 1993 (3,441 households and 13,893 individuals) and 1997 (3,875 households and 14,426 individuals). The ideal usage of the data will be to build a panel study for a sample of children and their household and community information across the four waves. However, when this study took place, the 1997 survey was not completely finished and some key variables such as household income and some community variables are not ready yet. More importantly, only a small proportion of the participants were given physical examinations, especially among children under 10 years old in each wave. And for the limited number of children who were given physical examinations in one wave of the survey, these same children have been missed in the other wave. Therefore, we have selected one wave of data to conduct a cross-sectional analysis. we use children under 10 years old whose physical examination information is available in the 1993 survey to be my study sample. we selected this wave because the quality of 1993 data is better than that of the 1989 and 1991 data and there are more community variables available (Carolina Population Center 2003).

In 1993, the height and other anthropometry information were measured for about 1,848 children who also can be merged into the household and community data. Therefore, this is the final sample for my analysis. Their height-for-age Z scores were calculated based on three variables (height, age and sex) by using the CDC computer software *EPIinfo 2002*.

Variables

The outcome variable is child stunting. Stunting is defined having height-for-age Z scores (HAZ) more than two standard deviations below the median reference standard for their age as established by National Health Center, Center of Disease Control and World Health Organization (NCDS/CDC/WHO). Based on the World Health Organization's recommendation (WHO Expert Committee on Physical Status 1995), malnutrition is the direct result of inadequate dietary intake, disease, and the interaction of these two factors (WHO, 1995). Stunting results from a long-term poor health and nutrition and some regard it as a better and more stable indicator since it is not subject to short-term fluctuation. Stunted children suffer an increased risk of mortality and morbidity. Stunting in infancy and early childhood can have consequences in later life, causing inferior capacity for physical work, reduced work productivity, and increased reproductive and maternal health risks (WHO Expert Committee on Physical Status 1995). Stunting has been included in the Millennium Development Goals (MDGs) as a key indicator to measure a country's development. The MDGs have been signed by almost all the United Nation member countries. The leaders of these countries promise to reduce current levels of child stunting and underweight by three quarters by 2015. Therefore, understanding the determinants of stunting has contemporary policy implications.

The independent variables are grouped into individual/household variables and community variables. The individual/household characteristics include child age, child sex, ethnicity (Han vs. non-Han), primary occupation (farmer vs. non-farmer), education level of the household head (educated refers to finishing elementary school) and

household wealth measured by an asset score. The primary occupation variable is a more valid measure of occupation than the place of residence (urban vs. rural) because, after the economic reform in China in 1978, many farmers migrated to urban areas for temporary jobs. But they remain officially labeled "farmers" by the household registration policy (Hu Gou policy) in China and are not covered by the urban community services. And in most cases, their children are left at their rural homes. Maternal education is not available in the dataset; we use the education level of household heads instead. Most household heads are typically the father, and some are the mother or grandparents.

The asset score is a synthetic wealth index intended to capture the household living standard (Filmer and Pritchett 1999b). It is constructed by applying the Principle Component Analysis (PCA) on various household durables (radio, television sets, bicycle, motorcycle, refrigerator, electricity, floor materials, drinking water sources, sanitation type, numbers of rooms etc.).

Consistent with my theoretical model, the community variables are divided into five categories: infrastructure score, health services, food market availability score, water and sanitation conditions, and family planning policy strictness score. The infrastructure score intends to measure the heterogeneity of community development levels, which is built based on the following questions: whether the community has convenient telephone, fax, postal services, daily newspaper, theaters, electricity, paved road, bus stop, train station, public bath, state enterprise, private enterprise, in-door restaurants. Similar with

the widely-used asset score, the infrastructure score is created by using the Principle Component Analysis (PCA). The major factor loading can be seen in the Appendix 1.

Health service variables include the number of doctors, number of midwives and number of hospital beds to represent the size of health services, availability of prenatal and X-ray checkup services to measure preventive and low-tech services, and availability of c-section service for delivery to represent the relatively high-tech and sophisticated health care services. To reflect the variation of food and other essentials availability and hopefully to capture the price variation in the market, we created a market availability score based on the availability of various foods (rice, flour, corn, millet, sorghum, oil, sugar, soy sauce, vinegar, vegetables, pork, chicken, beef, mutton, milk, fish, bean curd) and other living materials (fabrics, wool, cotton batting, coal, liquefied natural gas, gasoline, kerosene, piped gas) in both state store and free market. Similarly, we applied the Principle Component Analysis (PCA) approach to generate the scores for each community (See Appendix 1 of this chapter for its items and factor loading).

In China, the family planning policy can reflect the political atmosphere and some cultural norms in a community. A family planning policy strictness score is created by the Principle Component Analysis (PCA) to summarize the variation in the following questions: whether two children are allowed; whether there are exception to allow two children given that the first child is a girl, or handicapped; or parents with special occupations, or minority household; whether a fine is applied for one extra child; whether punishments are applied for breaking the policy including job loss, demotion, loss of access to housing distribution, loss of bonus, denial of child health care subsidies; can children who are born out of the plan be registered promptly; whether there are local

cadres implementing the family planning responsibility system; and whether given a subsidy for a couple who has only one child including ration supplies of food, better housing and child health care subsidies (See Appendix 1 of this chapter for its items and factor loading).

In addition, two more variables, percentage of population engaging in agriculture and whether the community has a primary school, are added into the model to capture more variation across communities and to remain parallel with previous studies.

Statistical Analysis

Since we are interested in studying the effects of the individual/household and community variables on the probability of stunting rather than child height as a continuous variable, my outcome variable is binary variable (stunting or not). A logit model is used to examine the association between stunting and its determinants.

$$Logit\ (P/(1-P)) = \alpha + \beta X_{ihj} + rX_j$$

Where P is the probability of suffering stunting; β and r are two vectors of coefficients to individual(i)/household(h) and community variables (j).

We first run the logit models for stunting for the whole sample. Then we split the sample by primary occupation (farmer vs. non-farmer), household wealth (40% poorest

households vs. 60% richest households), and education level of household head (whether finish elementary school) respectively. In doing so, we assume that all the slopes of the predictors in the model are different; therefore, we can investigate the predicting pattern among these sub-groups.

Finally, we use the whole sample and add some interaction terms to the final model to statistically test the difference of the slope for those key variables identified in the split sample.

The data is nested in three levels: individual, household and community. This violates the independence of observation rule for a regression model. This so-called cluster effect is addressed by adopting a White/Huber sandwich estimator (Stata Corporation 2001b).

FINDINGS

Overall, 21 percent of the children in the sample suffered from stunting. The disadvantaged households have a larger share of child malnutrition problem; 26.6, 25.2 and 25.9 percent children in farmer's households, wealthier families and with a less educated household heads have stunting problems respectively, compared with 12.1, 17.2 and 18.4 percent to their counterparts (Table 1).

The distributions of individual and household variables in table 4 indicate that the average age of children in our sample is about 5.5 years old and there are more boys than girls in the sample. Han ethnicity is the overwhelming majority among all stratified socioeconomic groups. The three socioeconomic variables (occupation, wealth and education) show some cross-association. For example, only 51 percent of farmers have

elementary school education, while non-farmers are over 82 percent. Non-farmers have almost twice the household assets of farmers.

At the community level, the advantaged households (non-farmer, wealthier, more educated) tend to live in a well developed community (with higher infrastructure score).

Table 1: Descriptive Summary of the Variable

Variable	N	All	Farmer	Non-farmer	Poor	Rich	Less educated	Educated
Outcome variables								
Stunting	1848	21.1%	26.6%	12.1%	25.2%	17.2%	25.9%	18.4%
Individual & household variables								
Age	1848	5.5 (2.4)	5.5(2.4)	5.6(2.3)	5.5(2.4)	5.5(2.4)	5.2(2.5)	5.7(2.3)
Sex: Boys	1613	54.4%	54.5%	55.5%	54.2%	54.5%	53.1%	55.8%
Ethnicity: Han	1826	86.1%	83.9%	90.5%	88.7%	83.6%	82.7%	88.8%
Occupation: farmer	1747	63.1%	n/a	n/a	83.9%	41.7%	81.8%	50.1%
Household head Education (>elementary)	1701	61.9%	51.0%	82.0%	54.5%	69.4%	n/a	n/a
Asset score	1528	3.0(1.4)	2.4(1.2)	4.0(1.2)	2.0(0.8)	4.5(0.5)	2.3(1.3)	3.3(1.4)
Community variables	*178*							
Infrastructure score	1848	-0.24(1.7)	-0.80(1.6)	0.60(1.5)	-0.73(1.6)	0.25(1.6)	-0.74(1.7)	0.49(1.7)
Market trading activity score	1644	0.25(2.3)	0.67(2.1)	-0.42(2.4)	0.54(2.2)	-0.03(2.4)	0.42(2.2)	0.15(2.4)
Source of drinking water: tap water	1848	54.0%	38.5%	77.8%	38.2%	70.0%	40.1%	62.9%
Source of drinking water: well water	1848	31.0%	39.7%	17.9%	42.4%	19.5%	38.7%	26.6%
Source of drinking water: others	1848	15.0%	21.8%	4.4%	19.4%	10.6%	21.3%	10.5%
% of population engaging in agriculture	1829	52.3%	67.5%	28.6%	65.5%	38.8%	59.7%	47.3%
Having a primary school	1794	81.3%	88.6%	69.7%	88.9%	73.7%	83.2%	80.6%
Number of doctors	1801	81(144)	38(86)	145(184)	39(77)	122(179)	66(135)	93(152)
Number of midwives	1801	22(29)	21(29)	22(24)	23(31)	20(25)	20(26)	23(29)
Number of hospital beds	1801	191(334)	82(185)	356(424)	88(179)	291(411)	157(315)	218(349)
Whether prenatal services available	1801	92.1%	91.2%	94.1%	93.4%	90.9%	90.7%	93.3%
Whether C-section services available	1801	56.8%	49.3%	69.4%	56.2%	57.4%	56.2%	58.3%
Whether X-ray checkup services available	1801	82.7%	80.7%	86.9%	83.1%	82.4%	83.2%	83.1%
Family planning policy tighness score	1848	0.31(2.0)	0.87(1.6)	0.59(2.16)	0.83(1.7)	0.22(2.1)	0.44(2.0)	0.24(2.0)

Note: Percentage is used for categorical variables. Continuous variables are described by their Mean and (Std. Dev.)

They also enjoy higher level usage of tap water. About 78, 70 and 63 percent of non-farmer, wealthier and with a more educated household heads have access to tap water respectively, in contrast with 39, 38 and 40 percent of their counterparts. The disadvantaged families usually live in a community with fewer doctors and hospital beds; however, the number of midwives does not differ substantially across the stratified socioeconomic groups. The availability of prenatal service and X-ray checkup is almost equivalent between the advantageous and disadvantageous households; however, the non-farmer families enjoy better available C-section services than the farmer households do. The disadvantaged households are subject to a more strict family planning policy. In addition, there are more opportunities for the advantaged households living in a community with a primary school.

The unadjusted odd ratios (Table 2) indicate non-farmer occupation, household head education, household asset at the individual and household level, better infrastructure, tap water, number of doctors and hospital beds and less strict family planning policy at the community level have a negative and significant association with stunting.

Table 2: Unadjusted Odds Ratio of stunting

Outcome: stunting =1		
Variable	Unadjusted Odds Ratio	p-value
Individual & household variables		
Age	1.070	0.041
Sex: Boys	0.870	0.277
Ethnicity: Non-Han	2.390	0.000
Occupation: non-farmer	0.380	0.000
Household head Education (>elementary)	0.640	0.001
Asset score	0.720	0.000
Community variables		
Infrastructure score	0.770	0.000
Market trading activity score	1.060	0.054
Source of drinking water: well water vs. tap	1.930	0.000
Source of drinking water: others vs. tap	2.150	0.000
% of population engaging in agriculture	1.010	0.000
Having a primary school	1.300	0.176
Number of doctors	0.997	0.000
Number of midwives	1.000	0.303
Number of hospital beds	0.998	0.000
Whether prenatal services available	0.820	0.402
Whether C-section services available	0.780	0.076
Whether X-ray checkup services available	1.030	0.864
Family planning policy strictness score	1.270	0.000

Before running the full model, we fitted two separate models to include only the individual/household determinants and the community-level determinants respectively. Table 3 and Table 4 show occupation and wealth at the household level, community infrastructure, family planning policy, availability of C-section services and sources of drinking water remains as significant determinants of stunting.

Table 3: Adjusted odds ratio of stunting for the individual/household determinants alone

Outcome variable: stunting=1		
Variable	Odds Ratios	p-Value
Individual & household variables		
Age	1.04	0.364
Sex: Boys	0.77	0.096
Ethnicity: Non-Han	2.23	0.001
Occupation: non-farmer	0.55	0.003
Household head Education (>elementary)	0.93	0.649
Asset score	0.86	0.028
Pseudo R^2	0.0711	

Table 4: Adjusted Odds Ratio of Stunting for the community variables alone

Outcome variable: stunting=1		
Variable	Odds Ratios	p-Value
Community variables		
Infrastructure score	0.82	0.000
Market trading activity score	0.99	0.718
Source of drinking water: well water vs. tap	2.03	0.000
Source of drinking water: others vs. tap	1.73	0.023
% of population engaging in agriculture	1.00	0.509
Having a primary school	0.96	0.851
Number of doctors	1.00	0.378
Number of midwives	1.01	0.128
Number of hospital beds	1.00	0.713
Whether prenatal services available	0.87	0.672
Whether C-section services available	0.61	0.011
Whether X-ray checkup services available	1.70	0.045
Family planning policy strictness score	1.10	0.034
Pseudo R^2	0.0468	

The results of the full logistic regression model on child stunting (Table 5) are reported for all children in the sample, for farmers and non-farmers, the rich and poor, and the educated and less educated household heads separately.

Individual and household variables: since the outcome variable stunting is derived from the age standardized height-for-age Z scores, as expected, age does not show a significant association with stunting. Being a boy can reduce the risk of stunting but only for the farmer households, which is consistent with the well-documented son preference phenomenon in rural China (Chu 2001). The minority ethnicity (non-Han) has an increased risk to have an under-height child, and the risk is significant for the whole sample and for the advantageous households (non-farmer, rich and educated). The disadvantaged households do not have a significant association between ethnicity and stunting after controlling for the community variables. The household assets appear to be taken advantage of only by the more educated households, who may be more efficient in converting the health inputs into child health. The primary occupation and education of the household head do not have significant associations with stunting. This finding is consistent with other studies (Penders et.al. 2000), suggesting that the community factors included in the model may have taken away some of the associations.

As a general pattern, the disadvantaged households have fewer significant variables at the individual and household level after controlling for the community variables than the advantaged families do, which may indicate that the community factors are more important to the disadvantaged households.

Community factors:

Community infrastructure plays a significant role in reducing the odds of stunting in the whole sample. But for the stratified samples, the significant reduction of stunting associated with a high infrastructure score only holds for the farmer, poor or less

educated households. Previous research (Sastry 1996; Penders 2000) identified a similar pattern. This agrees with my theoretical anticipation of a substitution effect: community infrastructure will help the disadvantaged households more; in other words, the disadvantaged families rely more on a better developed community to avoid child stunting. Conversely, they are more vulnerable to onslaughts of low development.

For health service variables in a community, the disadvantaged households are more sensitive to the variables representing the access to local health services. For example, there is a negative and significant relationship between the number of doctors and stunting, and positive and significant associations between the number of midwives and the number of hospital beds with stunting in the farmer households. Similarly in the less wealthy households, the number of doctors reduces the risk of stunting while the number of hospital beds increases it. Also finding that more nurses and support staff tend to be associated with shorter children in Ghana and Cote d'Ivoire, Lavy (1996) attributes the reason to the quality of services, arguing that doctors are a better indicator since they may provide better services as a result of better care and equipment. Taking quality of services into account, my findings consistently support a substitutive effect between the number of doctors and the disadvantaged status measured by occupation, wealth and education. On the other hand, the more sophisticated services, like Cesarean-section delivery services, only reduce the chances of stunting for the advantaged families (non-farmer and more educated households). This finding provides support to my claim that the efficiency-type health services — which require knowledge, skill and compliance — may complement individual characteristics.

Table 5: Adjusted Odd Ratio of Determinants on Child Stunting

Outcome variable: stunting=1

Variable	All	Farmer	Non-farmer	Poor	Rich	Less educated	Educated
Individual & household variables							
Age	1.04	1.03	1.01	1.00	1.12*	1.15*	0.98
Sex: Boys	0.87	0.64**	2.04*	0.88	1.25	0.76	0.86
Ethnicity: Non-Han	2.07**	1.81	3.29**	1.58	3.38***	0.80	2.46**
Occupation: non-farmer	0.71	n/a	n/a	0.74	0.62	0.66	0.73
Household head Education (>elementary)	0.82	0.87	0.71	0.82	1.12	n/a	n/a
Asset score	0.86*	0.82	0.94	n/a	n/a	0.98	0.80**
Community variables							
Infrastructure score	0.85***	0.85**	0.79	0.81***	0.94	0.70***	0.93
Market trading activity score	0.97	1.02	0.84**	0.99	0.90	1.00	0.94
Source of drinking water: well water vs. tap	1.42	1.34	1.69	0.98	1.33	1.32	1.44
Source of drinking water: others vs. tap	1.12	1.04	2.73	0.94	1.46	1.00	1.14
% of population engaging in agriculture	1.00	0.99	1.00	1.00	1.00	1.00	0.99
Having a primary school	0.97	0.84	1.82	0.93	0.65	0.69	1.21
Number of doctors	1.00	0.99***	1.00	0.99**	1.00	0.99	1.00
Number of midwives	1.01	1.01**	1.00	1.01	1.01**	1.00	1.01
Number of hospital beds	1.00	1.01**	1.00	1.01**	1.00	1.00	1.00
Whether prenatal services available	0.64	0.48	0.79	0.56	0.78	1.10	0.53
Whether C-section services available	0.64*	0.73	0.36**	0.67	0.71	1.00	0.53**
Whether X-ray checkup services available	1.48	2.15	0.82	1.78	2.00	0.84	1.68
Family planning policy strictness score	1.15**	1.22**	1.19	1.21**	1.19	1.19**	1.23
Pseudo R^2	0.0904	0.0838	0.1610	0.0551	0.1165	0.0955	0.1002

*:P<0.1; **: P<0.05; ***: P<0.01

There is a consistent effect of the family planning policy on stunting. Overall, a more restrictive family planning policy in a community is associated with an increases risk of stunting. After stratifying the sample into socioeconomic groups, it is only the disadvantaged families which are harmed by the family planning policy. Children in farmer, poor and less educated households all are sensitive to the policy and show an increased odds of suffering from stunting when family planning is tightened up.

As my conceptual model predicted, access to local food and living material markets only significantly associates with the non-farmer families for a lower risk of child stunting. We did not find any significant association between water and sanitation conditions with stunting. This may be due to two reasons. One, the effect of water and sanitation is possibly explained away by other community variables like infrastructure (although the correlation between them is acceptable to put them in the same model). Another is that the small sample size may reduce the power to detect the true effect.

The approach of stratifying the sample by the three household socioeconomic variables (occupation, wealth and education) and applying the logit model on the sub-sample made it possible to compare the different pattern of association between stunting and the independent variables. In doing so, we made an assumption that the slopes for all the independent variables are different. To actually test whether the slopes are statistically different for some key community variables, we need to work on the whole sample rather than the stratified sample and add some interaction terms in the regression model. The significant level of the interaction terms tells whether the slopes between the educated and less educated or between the poor and rich statistically differ. We only test

the interaction terms between education and wealth, and the community variables which show significantly different pattern between the stratified samples. The results in Table 6 suggest that the interaction terms between these community variables of concerns (infrastructure, family planning policy and availability of C-section services) and education are statistically significant, confirming the different slope assumption for these variables by the stratified individual variables. However, none of the interaction terms between the interested community variables (infrastructure, family planning policy, number of doctors, number of midwives and number of hospital beds) and household wealth are statistically meaningful, which provide little supports to the patterns observed in the stratified sample by household wealth. Similarly, Sastry (Sastry 1996a) also did not find the significant interaction terms between household income and community variables. He attributes the reasons to the possibility of survey error in income measure and of the poor representation of household's command over resources by household income. We did not test the interaction terms between occupation and community variables because famers and non-farmers usually face different resources and constraints in the health production function and it is more justified to run separate models for farmers and non-farmers than force them into the same model.

Table 6: Adjusted Odd Ratio for the Logistic Model with Interaction Terms on the Whole Sample

Outcome: stunting=1

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Individual & household variables								
Age	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
Sex: Boys	0.86	0.87	0.86	0.86	0.86	0.86	0.87	0.86
Ethnicity: Non-Han	2.01**	2.06**	1.99**	2.13**	2.12**	2.15**	2.14**	2.14**
Household head Education (>elementary)	0.99	0.70	1.05	0.80	0.81	0.81	0.80	0.81
Occupation: non-farmer	0.68	0.73	0.72	0.71	0.72	0.72	0.72	0.72
40% poorest (based on the Asset score)	1.18*	1.16**	1.18	1.57*	1.62*	1.59*	1.43**	1.65
Community variables								
Infrastructure score	0.75***	0.84***	0.84***	0.92	0.83***	0.83***	0.83***	0.83***
Market trading activity score	0.97	0.96	0.96	0.97	0.97	0.97	0.97	0.97
Source of drinking water: well water vs. tap	1.43	1.40	1.41	1.40	1.40	1.38	1.41	1.40
Source of drinking water: others vs. tap	1.14	1.08	1.12	1.12	1.11	1.14	1.11	1.15
% of population engaging in agriculture	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Having a primary school	0.93	0.95	1.00	0.92	0.91	0.96	0.94	0.94
Number of doctors	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Number of midwives	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Number of hospital beds	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Whether prenatal services available	0.64	0.63	0.62	0.64	0.64	0.63	0.64	0.63
Whether C-section services available	0.67	0.64*	0.85	0.64*	0.64*	0.65*	0.65*	0.64*
Whether X-ray checkup services available	1.45	1.48	1.53	1.46	1.46	1.49	1.46	1.49
Family planning policy strictness score	1.15**	1.08*	1.16**	1.14	1.23*	1.15**	1.16	1.15**
Interaction terms								
Education* infrastructure	1.24**							
Education* family planning policy		1.17**						
Education*C-section service			0.60*					
Wealth*infrastructure				0.89				
Wealth*(family planning policy)					1.10			
Wealth*(number of doctors)						1.00		
Wealth*(number of hospital beds)							1.00	
Wealth*(number of midwives)								1.00
Pseudo R^2	0.0946	0.0925	0.0925	0.0904	0.0904	0.09	0.0902	0.0901

*: P<0.1; **: P<0.05; ***: P<0.01

DISCUSSION

The question of complementarity and substitutability does not have a simple answer. The direction of the interaction between individual/household variables and community factors not only depends on which community and individual/household variables are being studied but also where the research takes place. Building on previous work, the framework developed in this paper provides some guidance in specifying the community variables and on the underlying mechanisms. My empirical findings basthe China data were consistent with the theoretical framework. In conclusion, increased access to local infrastructure, basic health services, plus the knowledge brought by the improved access serve as substitutes for the disadvantaged household characteristics (farmer, poor and less educated). On the other hand, local services intended to improve the efficiency of utilization, which requires a certain level of knowledge and skill, usually complement the advantaged household variables, such as those high quality and sophisticated health services and taking advantage of the variety of food and living material market. Family planning policy is a very important community dimension to a country like China. The study identified an association between stunting and the family planning policy especially in disadvantaged households. This may suggest the disadvantaged population is especially vulnerable to government policy and changes in the political environment. Having been missed in the previous studies, the political and policy dimension as well as measures of cultural norms should be properly addressed in the future research.

It is critical to discuss the issue of selectivity (or endogeneity in economic terms) when investigating the effect of community factors. The results of this paper may be

biased if the community infrastructure and services are not determined randomly or exogenously. For example, if there are some deliberate choices made by households to move to a better community (better infrastructure, higher concentration and quality of health services, or less restrict family planning policy) for the sake of the health of their children, some of the significant association may be contaminated by the intentional migration. Schultz (1984) and Rosenzweig and Wolpin (Rosenzweig and Wolpin 1986) have all emphasized the importance of addressing this issue. However, the options to correct the selectivity are limited. It is impossible to randomly assign household into communities with different levels of local infrastructure and services. Some statistical methods such as an instrumental variable (IV) approach heavily rely on the availability of some ideal variables. Most of the previous research has recognized the potential selectivity problem but has failed to find a proper solution for it. Lavy (1996) admits that poorer household are usually located in areas with fewer social services and Sastry (1996) points out the possibility of the selectivity problem, but both of them did not give specific solutions. We would argue that migration-based selectivity may be less of a problem in China given the presence of the household registration system (Hu Kou system). First, the system makes migration very difficult, especially from a rural area to a city; and second, it limits people's use outside the local registration roster of the local services and resources. Since the economic reform, some farmers have moved into cities for temporary jobs. But they are not entitled to enjoy the urban social services such as school and health services, not to mention that they simply cannot afford the services in most cases. Also, their children are usually left in the rural areas. To some extent, the registration system could ease the suspicion of the selectivity problem. However,

endogenous enforcement of policies and endogenous political performance remain as concerns. For example, the family planning policy may be endogenously enforced more where people are vulnerable and have little voice in the political systems.

Sample selection is another concern of this paper. If children who took the physical examination, therefore included in the sample, are not random and correlate with the individual/household socioeconomic variables and community factors in question, this may potentially bias the model estimation and harm the generalizability of the findings. To check the level of sample selection, we tabulate the children measured for height and children not measured by some common socioeconomic variables including race, income, education, occupation. The distributions of these variables between the two samples are very similar and the t-test failed to reject the null hypotheses (Table 7). Therefore, sample selection is less likely to have an effect on the findings.

Table 7: Household characteristics comparison to check sample selection

Variable	Children measured		Children not measured		p-value (ttest)
	% or mean	N	% or mean	N	
Race: Han	86.10%	1826	86.60%	12288	0.559
Household Income	5822 Yuan	1848	5992 Yuan	12570	0.109
Household Head Education (>elementary)	61.90%	1701	59.70%	10525	0.086
Occupation: Farmer	63.10%	1747	63.70%	7196	0.640

HH: household

The data used are cross-sectional, which lacks the ability to draw causal conclusions and to study the lagged effects of the key variables. The disadvantage of the concurrent predictors of stunting undermines the findings of this study. A better dataset would be panel data to take some unobserved fixed factors such as genetic endowment or

fixed component of tastes into account, and to allow the lagged outcome variable. We have tried to link the 1993 survey with other waves of the survey. Unfortunately, the same group of people did not take the physical examination in each wave and the already small sample size in 1993 survey does not allow me to build a reasonable size of panel dataset.

Some studies have made efforts to find some measures for the generic endowment. For example, a study (Thomas 1994) uses parents' height to control for the heterogeneity of generic endowment. There is no such variable in my data set, but we hope that it is not a significant problem in this study because we use stunting instead of a continuous height-for-age Z score as the outcome variable. Unless there is sizable misclassification around the international standard cut-off point, it would not change my findings significantly.

Some variables are not ideal. Maternal education is not available, and we use the education level of the household heads instead. This may change the interpretation of the education variable and make it less comparable to other studies using maternal education. Market prices, especially of foods, are suggested as an important predictor of child health by Schultz (1984) and Lavy (1996). However, the tremendous amount of missing data in the price variables stopped me from using them in the logit model. Instead we created an access index to food and living in material markets to hopefully capture the price variation.

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Appendix 1: Factor loading for the created community variables

This appendix contains factor loadings for the created community infrastructure score (Table 8), the food market availability score (Table 10) and the family planning policy strictness score (Table 11). We also tabulated the items in the community infrastructure score by stunting to help understand the contributions of each item to the effect of community infrastructure on child height (Table 9).

For the infrastructure score, the factor loadings of the items are roughly even and there is no one or two items dominating the loading. In the distribution table (Table 9) of the items by stunting, most of the items except the availability of daily news paper and train station show significantly different distributions between the stunting and not stunting groups.

Vegetable and bean curd store are the two items standing out in the food market availability score, with a factor loading of 0.73 and 0.65 respectively.

In the family planning policy score, denial with ration coupons for cooking oil for out-of-plan children has the largest factor loading of 0.74.

Table 8: Factor loading for the infrastructure score

Item	Factor loading
Paved local road	0.251
Telegraph services	0.393
Telephone services	0.404
Fax services	0.333
Postal services	0.276
Daily newspaper	0.243
Movie theater	0.372
Electricity	-0.008
Hours/day electrical power available	0.165
Bus stop	0.316
Train stop	0.179
Public Bath	0.207
Near a navigable rive	0.180

Table 9: Distribution (%) of the items in the infrastructure score by stunting

N=1848

Item	Stunting	Not Stunting	Chi-square P-value
Paved local road	37.5	45.0	0.019
Telegraph services	26.6	45.4	0.000
Telephone services	50.2	66.3	0.000
Fax services	15.0	26.8	0.000
Postal services	79.7	88.9	0.000
Daily newspaper	29.2	33.0	0.179
Movie theater	59.0	66.1	0.015
Electricity	99.4	99.4	0.925
24 Hours electrical power available	74.9	78.3	0.000
Bus stop	49.0	59.3	0.001
Train stop	16.8	20.7	0.109
Public Bath	8.9	12.9	0.043
Near a navigable rive	19.2	20.3	0.030

Table 10: Factor loading for the food market availability score

Item	Factor loading
State store (food grain)	0.1844
State store (vegetables)	0.7289
State strore (meat/poultry)	0.3153
State store (fresh milk)	0.2113
State strore (fish)	0.3439
Sate store (bean curd)	0.6516
State store (fuels)	0.4276
Free market (food grain)	0.1094
Free market (cooking oil)	0.0842
Free market (vegetables)	0.1111
Free market (meat/poultry)	0.1223
free market (fresh milk)	0.1915
Free market (preserved milk)	0.1420
Free market (fish)	0.1220
Free market (bean curd)	0.0864
Free market (fabric)	0.0598
Free market (fuels)	0.0730

Table 11: Factor loading for the family planning strictness score

Items	Factor loading
Even the first child is a girl, couple may not have another	-0.1246
Even the first child is a handicapped, couple may not have another	0.0147
Even both parents are noly child, couple may not have another	0.0181
Even parents are certain occupations, couple may not have another	-0.0464
Two children are not allowed at any circumstance	-0.0577
Regulations are same for minorities	-0.0673
Minority parents are not allowed two children	-0.0003
Minority parents are not allowed three children	0.0905
Subsidy is provided to one child couple	0.0502
Children outside the plan are not registered promptly	-0.0329
Children outside the plan are denied various ration subsidies before registration	0.0109
One-child families receive extra ration supplies of food	0.0400
One-child families obtain better housing	0.1293
One-child families receive child health care subsidies	0.1378
One-child families receive other subsidies	0.0355
Local cadres implemented the family planning responsibility system	-0.0173
Children outside the plan are denied with ration coupons for cooking oil	0.7391
Children outside the plan are denied with other ration coupons	0.3998
Lost work unit promotion when breaking the policy	0.2785
Lost access to house distribution when breaking the policy	0.3170
Lost work unit bonuses when breaking the policy	0.3257
Lost child health care subsidies when breaking the policy	0.3092
Lost other subsidies when breaking the policy	0.3324