Gender Bias Within Chinese Families—Who Eats First in Tough Times?

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Abstract

This paper investigates within family the effects of parental income shocks on individual's dietary intake. Drawing on large-scale panel data from the China Health and Nutrition Survey from 1991 to 2011, I examine the macronutrient intakes of 2 to 17-year-old siblings of mixed-sex and their parents in 3,244 families. Gender disparity in carbohydrate intakes accounts for 15 percentage points in child sample, 30 percentage points in adolescents, and 50 percentage points between parents using the Dietary Reference Intakes standards. The paper further shows that when families experience negative income shocks, food is allocated in the order of fathers, sons, daughters and mothers. Gender inequality of intra-household resource allocation is heightened in the event of large income losses.

"Food consumption in particular has been shown to serve as a symbol or a code, describing certain human relationships, such as inclusion and exclusion, and intimacy and distance. Eating may also tell us about ourselves for eating is a rutted habituation that is so close to the core of our memories, to the formation of our character and the launching of our conscious experience, that its substances may be said to become a part of us."

—Bernadine Chee, 2000

Introduction

This paper investigates the intra-household effects of negative income shocks on nutrition intakes of Chinese boys versus girls; mothers versus fathers; and children versus parents. Specifically, when an income loss occurs, whose food intake decreases most?

China has a long history of privileging male children. Parents treat the food their sons eat as a reflection of their improved economic status of the family, and no other mode of parent-child interaction communicates their love for their sons more than food

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(Jing, 2000). Many families, especially in rural areas, still treat sons as their own family members, while daughters will eventually be "married off", and leave the families. Therefore, it is common for parents to allocate income and resources from the daughter to son, especially when under a negative income shock when resources become scarce. Furthermore, sons are expected to support the parents when parents enter old age, especially in rural China. According to the China National Bureau of Statistics data in 2005, pensions cover 4.6% of elderly support in the rural area, while family support accounts for 54.1%(Dorfman et al., 2013). The majority of the old-age support is from private resources. Parents have the incentive to invest in sons, thus directly investing in their future pension. Son-priority could also be explained by the gender imbalance and the high competition faced by boys. The marriage rate of men in China is positively correlated with socioeconomic status, and females are equally likely to get married regardless of the socioeconomic status. Parents therefore are more likely to have higher expectations on their sons' performance and thus will allocate more food to their sons.

This paper fills three areas that are understudied in the literature. First, it is well-established that economic stress causes obesity (e.g. Smith, 2009; Offer, Pechey, & Ulijaszek, 2010; Rohde, Tang, & Osberg, 2017; Watson, Osberg, & Phipps, 2016) but the channel of the weight-gain is unclear. This paper examines the dietary changes under economic stress, which contributes to the relationship between obesity and economic conditions. Second, the existence of intra-household inequality is acknowledged as a problem in all societies, but few studies have investigated it due to the scarcity of data on resource allocation within households. This paper uses food intake, which is one of the most important kinds of resource in Chinese culture (Chee, 2000), to infer the inequality between boys and girls, fathers and mothers, and parents and children. Third, the effects of economic anxiety on health outcomes are mainly focused on adults, and little attention has been paid to children (except for Kong & Phipps (2016)). I investigate the effects of negative income shock on not only adults but also on the children. The finding has strong policy implications, as it suggests that families switch from the primary resource (protein) to an inferior resource (carbohydrate), which could affect children's development.

Novelties of this study include the following: 1) This paper provides the rare examination, if not the first, of full range of family dynamics in intra-household allocation of a scarce resource. 2) It observes 32,44 groups of siblings of mixed-sex in the same families as well as their parents in 12 provinces from 1991 to 2011 and followed them up to 5 times. 3) Son and daughter pairs within the households are compared to infer intra-household resource allocation. 4) The daily intakes of macronutrients, summarized into protein, carbohydrates, fat and energy categories, are recorded respectively for both siblings and their parents. The categories of nutrition intake shed light on not only the quantity but also the quality of the resource allocation. 5) The level of daily intake is adjusted for age- and gender-specific international standards.

The main purpose of the paper is to investigate the gender inequality within households using nutrition distribution. It enriches the literature that examines the changes in nutrition intakes in response to a negative income shock within the household, as well as documents the macronutrient intakes of Chinese children and their parents, especially compared to international standards.

Related literature

The study of inequality often neglects inequality among household members (Burton, Phipps, & Woolley, 2007). Equal sharing of income, consumption, resource and well-being within the household is commonly assumed. However, a growing number of studies point out the importance of intra-household allocation. For example, Phipps & Burton (1995) discover that individual well-being is sensitive to income-sharing assumptions. Lise & Seitz (2011) estimates that the Gini coefficient could increase by 30% after accounting for consumption inequality within U.K. households.

Even if the existence of household inequality is recognized, the study of intra-household inequality is largely restrained by the data availability as the income is usually collected at household level (Osberg, 2000). Researchers have adopted different dimensions such as time, consumption, health and satisfaction to estimate the inequality within the household. For example, Burton, Phipps, & Woolley (2007) includes home production in income inequality. Phipps, Burton, & Osberg (2001) demonstrate the inequality of free time for self among dual-earner households, and women are more likely stressed about weekly hours, despite the total hours of labour supply. Osberg (2015b) uses self-reported food deprivation in Tanzania and finds the elderly rural women are more likely to suffer from hunger. He highlights the gendered intra-household inequality and the demonstrates the importance of including such inequality into poverty measurements and pension designs.

Apart from inequality between spouses in the household, intra-household inequality also exists between parents and children, as well as sons and daughters. Lundberg, Pollak, & Wales (1997) shows an increase in children's clothing expenditure if the family allowance is directly paid to mothers. (Burton, Phipps, & Woolley, 2007) uses the age difference between couples in the eligibility of receiving the Old Age Security in Canada, and the result suggests that the increase in women's income leads to a larger expenditure on gifts (possibly to grandchildren). Haddad & Hoddinott (1994) uses data from Cote D'Ivoire and discover that an increase in women's cash income leads to an increase in boys' height-for-age relative to girls'. (Duflo, 2000) uses the expansion of the Old Age Pension program in South Africa and finds an improvement in girls' health and nutrition. To my knowledge, most research on intra-household inequality uses exogenous increases in income to investigate the resource allocation. Few studies have been done using an income fall.

I am particularly interested in food intake for three reasons. First, nutrition during childhood has long-term effects on the development of cognitive skills and the productivity later in life (e.g. Dasgupta, 1995). Such effects are particularly important in developing countries (Duflo, 2000). Second, Chinese culture is highly food-oriented (Chang, 1977), and food serves as a symbolic value of love. The process of deciding which foods to eat, who will eat them, and how much to eat provides a path to understanding their everyday lives, and draws a vital picture of their relationship with other people. The food allocation shapes the family dynamics between parents and children, sons and daughters, reflecting the pleasures and pressure of family members (Chang, 1977).

Third, people of different cultures, geographies, and ethnicities eat different food and have different ways to prepare and cook food. For example, southern Chinese people tend to eat rice and favour sweet flavours, while northern Chinese cuisine features wheat and a salty flavour. Western Chinese cuisine serves hot and spicy meat based dishes. The differences in the food items, flavour, and cooking methods can all be measured in calories, carbohydrates, proteins, and fats. Such measures make them comparable resource indicators across culture, ethnicity, and economic status and over time[1]. Despite the emphasis on food in Chinese culture, only a few studies have examined food intake in China. For example, Jing (2000) adopts a sociology perspective and conducts case studies in municipalities such as Beijing and Xi'an to portray the changes in food intake under the rapid socioeconomic development of China. Chang (1977) examines the evolution of food culture over the history of five thousand years. The only quantitative research has been done focused on child food intake in contemporary China at a national level is Cui & Dibley (2012). They present the trend of dietary intake of Chinese children aged 7 to 17 using the China Health and Nutrition Survey (CHNS) data. They show a steady decline in energy and carbohydrate intake, and a steady increase in fat intake from 1991 to 2009. The value of daily protein intake decreases, but the ratio of protein-energy ratio increases slightly. However, Cui & Dibley mainly focus on the nutrition transition to a fat diet, and do not examine the income changes, sibling disparity, and parent-child interactions.

Past literature has linked stress with changes in eating behaviour. Smith (2009), Offer et al. (2010) and Köster & Mojet (2015), among other studies, describe food that is high in fat and carbohydrates as comfort food, and is served as self-medication; providing immediate relief from negative emotions. In other cases, Macht (2008), Köster & Mojet (2015), and Staudigel (2016) discover that stress could also reduce appetite and food intake. The bi-directional effects of emotion show that stress controls, suppresses, impairs, regulates, or harmonizes eating behaviour. On average, Macht (2008) shows that emotional stress induces 30% people to increase while 48% people to decrease in food intake using survey data. Staudigel (2016) uses Russian panel data and demonstrates economic insecurity reduces women's body weight. He also discovers a strong link between economic insecurity and sugar consumption.

In the Chinese context, Liu et al. (2007) examines the relationship between types of food consumed by college students in seven cities and their stress and depression measures. They find that the consumption of ready-to-go food (such as instant noodles, frozen, canned or microwavable foods), snack foods (such as potato chips, corn chips and tortilla chips) and fast food (such as McDonald's, KFC, Pizza Hut) is positively correlated with perceived stress level depression scores. They do not establish the causal relationship between stress and eating behaviour. No research thus far examines the intergenerational dietary change resulted from economic stress. This paper is also the first study in Chinese context to examine the dietary change of parents and children in response to an economic shock.

[1] In the fixed effects estimation, I examine the changes in marcronutrient intakes are examined within the same household. Energy, carbohydrate, protein, and fat intakes provide comparable measures of resource allocation.

Data

The CHNS dietary intake data

The data of analysis are from the China Health and Nutrition Survey (CHNS) from 1991 to 2011 (eight cycles). The CHNS is the only large-scale longitudinal data set (Popkin et al., 2010) conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention. It covers 12 provinces that vary in geography, demographics and socioeconomic development (*China Health and Nutrition Survey*, 2017). Figure 1 presents the provinces that are covered by the CHNS data. Within each province, the sample is stratified by one low-, two middle- and one high- per-capita income county or city. The township capital and three villages in the county or the urban and suburban areas in the city are randomly selected. Twenty households are then randomly selected for the survey. All household members are interviewed. Children younger than 10 years old are assisted by parents. Community, household, and individual level data are collected. The CHNS is representative of more than half of the population in China. There are 12,944 households and 16,066 children in the 1991 cycle. In 2011, there are 15,508 households and 22,977 children in the survey.

The CHNS hosts several features that make it particularly attractive for this study. First, the longitudinal nature of the data enables me to observe families for up to 14 years [2] During the 14 years, the rapid economic development accompanied by the economic reforms takes place and creates a rare opportunity to study negative income shocks. In the data 11.6% of the sample, which amounts to 646 children, experience large negative income shocks (defined as 25% of income loss). Second, the CHNS not only provides information on the household heads, but also every household member, including fathers, mothers, sons and daughters. The ability to identify the relationship of household members enables studies on intra-household dynamics and inequality. Third, the wide range of survey sample of 12 provinces with both urban and rural areas enables me to observe 3,244 families with children of mixed-sex, which is a rare find in China under the One Child Policy. Fourth, the CHNS collects dietary intake information of all household members over the course of three days. The collection of dietary intakes is on a 24-hour-recall basis, and employs strict measures of changes in food stock, making the data quality objective and precise. The detailed information of dietary intake data collection and calculation is the following:

Food intake is measured at the household level as well the individual level (i.e. both children and parents) over three consecutive days of the survey. The three survey days are randomly distributed across seven days of a week. The household level of food intake is calculated by the change in food inventory from the beginning to the end of each day. It is measured with a weighing and measuring technique using Chinese balance scale ranging from 20 grams (*1 liang*) to 15 kilograms (*30 jin*). The nutritionists measure all the food items before the initiation of a 3-day survey period (a_0), all purchases and home production (a_1) during the survey period, and the food discarded and remaining food at

[2] The CHNS panel runs from 1991 to 2011. The number of occurrences is also restrained by the age of the child in the sample (2 to 17 years).

the end of each day (a_2). The food consumption of household level is therefore defined as $a_0 + a_1 - a_2$.

Every household member reports all food consumed at home and away from home on a 24-hour recall basis[3]. Mothers or caregivers who handle food preparation are asked to recall the food consumption of children younger than 12 years old. Nutritionists record the types of food and snacks, the method of cooking, as well as the time and place of consumption. Mothers, or those who handle the food preparations, together with other household members provide information on shared dishes to determine the amount of individual intake. More than 99% survey respondents have reported full three days of data (*China Health and Nutrition Survey*, 2017).

To calculate the daily intake of macronutrients including carbohydrates, fat, protein, and energy, the 1991 Food Composition Table for China is used as an average amount on a dish-by-dish basis for survey cycles prior to 2004. The 2002 Food Composition Table is used in the subsequent surveys cycles of 2004, 2006, 2009 and 2011.

The CHNS implements strict quality control procedures. It follows the Declaration of Helsinki, and the survey protocols, instruments, and process are approved by the institutional review committees of the University of North Carolina at Chapel Hill. The written consent was obtained from all survey respondents. The food intake at the household level is matched with the individual level data. If a significant discrepancy is found between the sum of individual level data and the household data, the CHNS revisits the family to resolve the inconsistency. Field workers are trained nutritionists who have post-secondary degrees and professional work experience in nutrition. The CHNS also provides three days of training on dietary data collection to the field workers before the survey (*China Health and Nutrition Survey*, 2017).

Dietary Reference Intakes (DRIs)

I use the Dietary Reference Intakes (DRIs)[4] to adjust for the nutrient needs according to the growth of children and the gender- and age-specific requirements for parents (see Table 1). The DRIs table is developed by the Institute of Medicine at the National Academies of Sciences Engineering Medicine and is widely used in many international studies including the U.S. Guidelines for Americans, National Health and Nutrition Examination Survey and the Canadian Community Health Survey. It provides guidelines in daily consumption of energy, carbohydrate, protein and fat intakes for 97% to 98% healthy individuals to meet nutrient requirements. The values are based on the recommended Physical Activity Level (PLA) of 1.6 to 1.7 in healthy individuals, which means the total energy consumption is 60% to 70% of the resting energy expenditure, and it is equivalent of 60 minutes of daily physical activity (Trumbo et al., 2002). The DRIs also take into account pregnant and lactating women, as these special stages require higher levels of nutrition intake. The adjustments are used when the analysis is done for children's mothers in the later section.

[3] According to the CHNS, 12% breakfast, 11% lunch and 5% dinner are consumed away from home. Home cooking accounts for 70% to 80% during the three-day survey period.

[4] There are other food intake standards, such as the adult equivalence scale of food energy intake as adopted in Osberg (2015b). The advantage of the DRIs standards is that it provides not only the overall calorie intakes but also the protein, carbohydrate, and fat intakes.

The dependent variable is children or parents' percentage deviation in macronutrient intakes from the DRIs in the age- and gender-specific group[5].

$$IntakeDev_i = (Intake_i - DRIs)/DRIs \tag{1}$$

Table 2 shows summary statistics using the pooled sibling sample (with and without negative income shocks). A high-carbohydrate and low-protein diet is found in boys, girls, fathers and mothers. For example, the carbohydrate intake is 152.9% for boys and 138.7% for girls relative to the DRIs standards, while the protein intake is only 70.3% for boys and 59.7% for girls. This result is consistent with previous findings of lower protein-energy ratios in developing countries (Millward & Jackson, 2003). The overall energy intake is 110.7% for boys and 99.8% for girls. The fat intakes are 60.2% for boys and 51.5% for girls.

In all macronutrient categories, consistently lower intakes of girls are observed compared to boys in the same families with gaps ranging from 9 to 15 percentage points. Their parents' nutrition intakes exhibit the similar patterns as the children. On average, fathers of boys' energy intake is 169.3% while mothers of boys' intake is 143.5%. The discrepancy highlights gender differences in dietary intakes among parents.

Table 2 also validates the sample of selection for boys and girls. Statistically identical results are shown between the parents of girls and the parents of boys. For example, when comparing the energy intake for mothers of boys to mothers' of girls, the average is 143.5% for both. The result suggests that the girls and boys are selected from the statistically identical sample.

Negative income shock and its reasons

Hacker et al. (2014) propose the "Economic Security Index" using the frequency of a 25% decline in individual net CPI-adjusted income from one year to the next. I adopt this criterion of a "large" income shock and define the negative income shocks as the equivalent income loss (from all sources) more than 25% of the average of most recent three income observed[6].

$$\begin{aligned} NegShock_{it} &= 0 \qquad \text{if } \frac{Y_{it} - \bar{Y}_i}{\bar{Y}_i} > -0.25; \\ NegShock_{it} &= 1 \qquad \text{if } \frac{Y_{it} - \bar{Y}_i}{\bar{Y}_i} \leq -0.25 \end{aligned} \tag{2}$$

where Y_{it} is equivalent income of current cycle (i.e. family income from all sources divided by square root of household size); and $\bar{Y}_i = (Y_{it} + Y_{it-1} + Y_{it-2})/3$. Data are trimmed so that negative income is equal to zero. I ignore negative income because many families who are in business, farming, gardening, fishing, or raising livestock report negative income. The nature of such business is to invest for a few years and thus generating negative income, but a large return in the future is expected (*China Health and Nutrition Survey*, 2017).

[5]The raw intakes are trimmed so that the observations above the top and below bottom 1% are equal to the top and the bottom 1% respectively.

[6]The 25% income fall from the recent three-year average may lead to a larger income shock than from the previous year. I also examine the 25% income loss from the previous year and the results are highly consistent.

Types of economic risks. Osberg (1998) outlined four aspects of economic risks identified in *the United Nations' Universal Declaration of Human Rights*: unemployment, illness, family dissolution, and old age. In the CHNS data, the four risks can be identified by the following questions:

- Unemployment: Changed or lost jobs since the last survey.
- Illness: Self-reported health of 1 or 2 on a 4-point scale, or self-reported hypertension, diabetes, myocardial diseases, stroke or cancer.
- Family dissolution: Single, divorced, widowed or separated.
- Old age: male older than 60 and female older than 55[7].

For simplicity, the child is coded in the category if either parent is in the category. Table 3 shows the percentage of children associated with each economic risk by families with or without a significant negative income shock (25% of equivalent income loss). For children who experience a negative income shock in the family, 35% experience illness of parents, 17% have unemployment, 3% have family breakups, and 0.3% have old aged parents. The families without negative income shock have a lower economic risk in each category except for old age.

Dietary knowledge. The CHNS also asks respondents 12-year and older diet knowledge in the cycles 2004, 2006, 2009 and 2011. To infer the overall energy intake, fat, carbohydrates, protein and body image, the five questions are selected: *Do you strongly agree (5), agree, neither agree nor disagree, disagree or strongly disagree (1) with the following statements:*

- *Eating a large amount of sugar is good for health.*
- *Eating food high in fat is good for health.*
- *Eating a large amount of staple food is good for health.*
- *Eating a large amount of animal products (e.g. fish, poultry, eggs, and lean pork) every day ia good for health.*
- *The heavier you are, the healthier you are.*

Table 3 shows the mean and standard deviation of each question answered by children in the families with and without negative income shock. Children experiencing a negative income shock rated higher for all questions compare to children without a negative income shock.

Child sample

The sample of this study consists of children of 2 to 17-year-old[8] in the survey years of 1991 to 2011. The birth cohort of the children is from 1973 to 2009. In the CHNS children sample, 36% of the children are from only-child families and 3,357 children have had one or more siblings of the opposite sex[9].

I limit the sample of analysis to families with more than one child of the opposite sex for sibling fixed effects analyses. At least one girl and one boy are observed in each

[7] The average retirement age in China is 60 for men and 55 for women (Dorfman et al., 2013)

[8] Children and infants who are younger than 2-year-old are likely breastfed and the dietary intakes are thus incomparable.

[9] I also investigate if the first borns are favoured in families with children of the same sex. No significant patterns are found

family, and at least two children are observed in each family in each nutrition survey year. The sample consists of 3,243 children and 1,364 households, with 20% of children observed four times, 28% three times, and 34% twice in the longitudinal sample.

There are 2,667 boys and 2,908 girls in the sample (see Table 2). The average birth order for boys is 1.9 and for girls is 1.6. The difference is statistically significant, and it can be explained by the One Child Policy, which permits the second birth in rural area if the first child is a girl. Other demographic variables are consistent across genders. In the sample, 11.4% of boys and 11.8% of girls experience negative income shock (25% income decline than the average in recent three cycles). On average, the equivalent household income is 7325 CPI-adjusted-2006 Yuan. Rural children account for 81% of the sample. On average, there are 2.5 children and 2.5 extra household members in a family. In the sample of analysis. 33% of children have completed primary schooling, and 20% have completed middle schooling. 43% of the children reached the age of puberty.

Siblings under the One Child Policy

How does the sibling sample in this study compare with the only-child sample? Even under the China One Child Policy, siblings are still commonly observed in Chinese families. Culturally and historically, Chinese families are in favour for having more children. Mao Zedong, the chairman of China from 1949 to 1976, advocated "more people, more power" and believed a rising population is a major drive for economic growth. After Mao's death in 1976, Deng Xiaoping took power. Deng believed in population control and promoted the growth in GDP per capita. The Chinese government thus enacted the One Child Policy in 1979 (Peng, 1991).

The One Child Policy was resisted by Chinese families, especially in the rural areas. In 1984 and 1985, the communist government relaxed the policy so that rural families with one daughter could have a second child. The fertility rate, therefore, rebounded from 1984 to 1986. Besides of the less stringent implementation in rural areas, the One Child Policy was also relatively relaxed in less developed provinces and ethnic minority groups. Figure2 shows the fertility rate in the urban and rural area from 1973 to 2009. The fertility rates were 5 and 2.4 in the rural and urban area respectively in 1973, and the figures became 1.4 and 0.96 in 2009. Therefore, for the birth cohort of this study from 1973 to 2009, it is common for Chinese families to have siblings.

Figure 3 presents mean and standard errors of percentage deviation of children's and parents' macro-nutrient intake from the DRIs standards by gender and only-child status. Protein intakes of Chinese children in all groups are significantly lower than the international standard. Boys have more protein than girls in both only child and non-only-child families. On average, Chinese boys in non-only-child families have 79% of the protein, comparing to Chinese girls in non-only-child families having 68% of the protein using DRIs standards. In only-child-families, the protein intake is higher for both genders—83% for boys and 76% for girls. Fat intake shows the same pattern as the protein intake with a smaller gap from the DRIs standards. On the contrary, carbohydrate intakes of Chinese children are relatively high, especially in non-only-child families. Boys with siblings consume 130% and girls with siblings consume 120% of carbohydrates intake standard. Carbohydrate intakes are 107% and 76% of the DRIs standards for only-child boys and girls respectively. The total energy intake is highest among boys with siblings, and lowest among only-child girls.

The shortage of protein intake and excess of carbohydrate intake are even more prominent among parents. Fathers' protein intakes range from 36% to 41% of the international standard, while father's carbohydrate intake is 1.7 to 2.4 times of the international standard. Mothers, on average, consume 48% of protein, and 1.7 times carbohydrates of the DRIs standards. Both mothers and fathers consume smaller amounts of fat in non-only-child families than those in only-child families, but higher total energy intakes contributed by high carbohydrate intakes[10].

Empirical framework

Sibling fixed effect model

In economic literature, most studies on children estimate child outcomes on a set of observables of family and child characteristics. Two concerns are raised by this approach, unobserved heterogeneity and income endogeneity (Dahl & Lochner, 2012). Mayer (1997), among others, suggests that the estimation omits unobserved heterogeneities across households. For example, children's outcomes could be driven by factors (neighbourhood, family environment and child's ability) other than income. In the Chinese context, the One-Child Policy boosted gender selection practice using ultrasound technology since its introduction in the 1980s (Chen et al., 2013). The availability of gender-selected abortions differs across provinces, urban or rural, economic status and family values, which contributes to the selection bias of girls and boys families. It is possible that girls may be more likely from disadvantaged families because their families cannot afford ultrasound scanning or abortions.

To remove the permanent unobserved family and children characteristics, I use sibling fixed effects as adopted by Blau (1999) and Levy & Duncan (2000). I estimate the differences in dietary intakes between brothers and sisters within the same households. Differences in family levels across siblings are removed when estimating the impacts of negative income shocks on child outcomes. The fixed effects model also enables me to compare the dietary intakes with and without negative income shock, and thus estimating the changes in dietary intakes in response to negative incomes. I employ three estimations on children, parents, and the combination of parent-children.

First, I estimate child dietary intakes with sibling fixed effects as follows:

$$IntakeDev_{ijt} = \alpha_j + \beta_0 NegShock_{jt} \cdot Girl_{ij} + \beta_1 NegShock_{jt} + \mathbf{\Gamma_1 X_{jt}} + \mathbf{\Gamma_2 W_{ijt}} + \epsilon_{ijt} \quad (3)$$

where i indexes individuals (i.e. children in this equation), j indexes families, and t indexes survey year. *IntakeDev* is percentage deviation of energy, carbohydrate, fat and protein intake from the age- and gender-specific Dietary Reference Intake standard. X is a vector of family-specific characteristics. W is a vector of observed child-specific characteristics. Standard errors are clustered at the family level.

[10] I examine the intergenerational gender inequality among only-child families using propensity score matching, and found that the gender inequality is only significant among families with children of mixed-sex.

The sibling fixed effects are captured by α_j, which reflect unobserved permanent family characteristics.The hypothesis is that $\beta_0 < 0$, which suggests in response to negative income shocks, girls reduce their macronutrient intakes more than boys in the same families.

Second, I examine the parents' dietary intakes using the same children's sample.

$$IntakeDev_{ijt} = \alpha_j + \beta_0 NegShock_{jt} \cdot Mother_{ij} + \beta_1 NegShock_{jt} + \mathbf{\Gamma_1 X_{jt}} + \mathbf{\Gamma_2 W_{ijt}} + \epsilon_{ijt} \quad (4)$$

where i indexes individuals (parent in this equation). The dependent variable $IntakeDev_{ijt}$ is percentage deviation of the father or the mother's energy, carbohydrate, fat or protein intake from the DRIs standards. $NegShock_{jt}$ estimates the overall effects of negative income shocks on both the father and the mother, and $NegShock_{jt} \cdot Mother_{i}j$ captures the extra effects on the mother in the same household.

Third, I combine the child sample and the parent sample estimated above, and test if parents shield their children from dietary reductions when economic hardships strike. By estimating the dietary intakes of two generations, I can investigate the resource reallocation among fathers, mothers, sons and daughters in the same households.

$$\begin{aligned} IntakeDev_{ijt} = \alpha_j + &\beta_0 NegShock_{jt} \cdot Girl_{ij} \\ &+ \beta_1 NegShock_{jt} \cdot Mother_{ij} \\ &+ \beta_2 NegShock_{jt} \cdot Father_{ij} \\ &+ \beta_3 NegShock_{jt} + \mathbf{\Gamma_1 X_{jt}} + \mathbf{\Gamma_2 W_{ijt}} + \epsilon_{ijt} \end{aligned} \quad (5)$$

where i indexes family members. The base of $NegShock$ effects is boys, and the interaction terms of $NegShock$ with girls, mothers and fathers capture the extra effects on each individual.

Other controls

For all sibling fixed effects estimation, I present 3 specifications. First specification controls the number of children in the families, if there is/are grandparent(s) or relatives present. The second specification adds if the child graduated from primary school or middle school, the birth order of the child, and if the child entered puberty [11]. The last specification adds the log equivalent income of the current period[12].

Figure 4 shows the means and standard errors of independent variables by child gender and only-child status. There are 10% of non-only-child families in the pooled sample experiencing negative income shock, while only 6% of only-child families had negative income shock. The only-child and non-only child families differ in demographic characteristics. According to Figure 4, only-child families have more household members other than children and parents. There is a higher percentage of only-children who completed middle school than non-only children. Equivalent income is 7,738 for non-only-child families and 14,770 for only-child families. 80% non-only child families and 59% of the only-child families are in rural area.

[11] Girls entering puberty if the answer is "Yes" to the question "Have you ever menstruated?" and boys entering puberty is defined as at 11 to 18 (Zhu et al. (2013)

[12] Equivalent income is defined as household income from all sources after tax and transfer in 2006 *Yuan* divided by the square root of household size (*Luxembourg Income Study*, 2017).

Results

Boys and girls' intakes

Table 4 shows the estimates of child nutrition intake using sibling fixed effects. The hypothesis is that negative income shocks affect boys' intakes less than girls', i.e. sons are favoured during tough times. I examine three nutrition intakes, carbohydrates, fat and protein, as well as the overall energy intakes (the combination of the three nutrition). For each outcome, I use three specifications: the first one controls for time-variant household characteristics; the second one controls for household characteristics and child-specific characteristics; and the third specification adds the current equivalent income as control. While the variables of interests are negative income shock and its interaction(s), equivalent income in fixed effects model also captures the changes in income. Therefore, the second specification is the preferred specification. The income variable is added in the third specification to estimate the "extra" critical point effects of 25% income fall.

Column 1 in Table 4 shows energy intake of children increases in response to a negative income shock, controlling for family characteristics. A 25% of income shock increases energy intake by 9.9 percentage points in terms of the DRIs standards. After accounting for household and child characteristics, the interaction of negative shock and girl becomes significant. Girls reduce their energy intake by 7 percentage points, while boys' energy is not significantly affected.

Carbohydrate intake is also significantly affected by negative income shocks. Column 4 shows that carbohydrate intake increases by 21.3 percentage points for boys, and by 13.9 (=0.213-0.074) percentage points for girls. After controlling for child-specific characteristics, the estimation still shows a 12.4-percentage-point increase in boys, but a 2.4-percentage-point decrease in girls. In the preferred specification in Column 6, a 14-percentage-point increase in boys, and a 0.5-percentage-point decrease in girls is estimated after controlling for income.

The sibling fixed effects estimation shows that protein intake reduces for both girls and boys when income falls 25% (see Columns 10-12, Table 4). With controls for families observed and permanent unobserved characteristics, boys' protein intakes decrease by 15.2 percentage points, and girls' protein intakes decrease by 24.9 percentage points. The magnitude of reductions is significant considering the average of protein intake is only 70.3% of DRIs standard for boys and 59.7% for girls. The results persist even after controlling for income. There is a 16-percentage-point decrease for protein intake for all children. The interaction term of negative shock and girl becomes insignificant.

On the contrary to the previous finding of a positive relationship between fat diet and economic insecurity, no change in fat intake of children is found due to negative income shocks.

Sample of adolescents. Adolescence is a critical transition period, and many biological, psychological and social roles are formed during this life stage. It is the foundation of future development (Sawyer et al., 2012). I limit the sample to adolescents and test if the gender disparity is larger during this life period. The adolescent sample is defined as girls from menstruation to 17-year-old and boys from 11-year old until 17-year-old (*World Health Organization*, 2017). There are 1,391 boys and 1,005 girls in the adolescent sample, which accounts for 43% of the full sibling sample[13].

Table 5 presents the sibling fixed effects estimates of dietary intakes on negative income shocks. Columns 1 to 3 show that daily energy intake is significantly reduced by 18.2 to 21.1 percentage points in the presence of negative income shocks for girls, while no reduction of energy intakes for boys. This result is consistent across three specifications. This result suggests a higher gender disparity among adolescents than the previous estimate with full sibling sample.

Girls also experience a large decrease in carbohydrate intake. After controlling for household and child-specific characteristics, the carbohydrate intake decreases by 29.4 percentage points for girls. Boys, on the contrary, is estimated a 24.4-percentage-point increase in carbohydrate intake in Column 6. After controlling for income, girls still experience a 5-percentage-point of carbohydrate intake reduction, which is a 29.4-percentage-point difference between boys and girls. This result suggests that the boys eat more and the girls reduce their carbohydrate intakes in response to a negative income shock.

Negative income shocks have negative effects on the fat intake of adolescent girls. Columns 7 to 9 in Table 5 show the fat intake reduces by 18.2 to 20.1 percentage points for girls. Boys fat intake show no significant change. The average fat intake for girls is only 51.5% of the DRIs standard, while for boys is 60.2% (see Table 2). The reduction in fat intake due to the negative income shock puts adolescent girls in a more disadvantaged diet than their boy counterparts.

The protein intake is estimated to be negatively affected by income shock for both genders (see Column 10 in Table 5). Boys' protein intake is estimated to be reduced by 11.0 percentage points, while girls are expected to reduce a further 8.5% in protein intake, totalling 19.5-percentage-point reduction. The effects on both girls and boys become insignificant after controlling for income.

Overall, the estimates of the adolescent sample show a larger gender disparity between boys and girls within the household. In response to negative income shock, girls in the adolescent sample intake 19.3 percentage points less of energy, 29.4 less of carbohydrate, and 19.6 less of fat, compared to boys in the same households. Considering girls have lower intakes than boys using the DRIs standards, the dietary reductions from the income loss is particularly problematic.

Fathers' and mothers' intakes

Table 6 presents the estimates of parents' dietary intakes with family fixed effects. The hypothesis is that mothers take a larger dietary cut than fathers in response to negative income shocks. The differential effects of negative income shock between mothers and fathers are captured by $NegShock \cdot Mother$.

Columns 1 to 9 show negative coefficients of $NegShock \cdot Mother$, which means mothers reduce energy, carbohydrate, and fat intakes significantly more than fathers. The estimates are highly consistent across three specifications. Compared to fathers, mothers reduce 29 to 31 percentage points more in energy, 47 to 50 percentage points more in carbohydrates, and 25 to 27 percentage points more in fat intakes in response to negative income shocks. The only exception is protein intake. On average, a 6.02-percentage-point

[13] I also examine the early childhood sample of 2-to-5-year-olds, as Heckman (2011) outlines the importance of invest in the early years. I do not find a significant gender disparity in the sample of early years.

reduction is found in fathers protein intake, while a 1.75 (=-0.0602+0.0427)-percentage-point reduction in mothers' protein intake. There is no evidence of significant reduction in father's dietary intakes except for protein intakes. On the contrary, an increase in carbohydrate intakes of 12.6 to 19.1 percentage points is found in specifications 1 and 2 (see Columns 4 and 5 in Table 6)

Parents' and children's intakes

Table 7 presents the family fixed effects estimates of both parents and children using the same sample of siblings of mixed-sex. The coefficient of $NegShock$ is the overall effects of negative income shocks on the family, and the interactions are the extra effects on girls, mothers and fathers using boys as the base.

The results are mostly consistent across three specifications. For simplicity, I use specification 2 for result interpretations. Negative income shocks significantly reduce energy, carbohydrate, and protein intakes of boys. Fathers experience increases in energy, carbohydrate intakes. Girls reduce energy, carbohydrate, fat and protein intakes more than boys in the same families. The gaps of the macronutrient intakes between boys and girls are 11.3 percentage points in energy and 17.5 percentage points in carbohydrates, 7.63 percentage points in fat, and 6.01 percentage points in protein. Mothers in the same families reduce intakes the most. On average, mothers reduce additional 14.0 percentage points in energy, 18.6 percentage points in carbohydrates, and 18.4 percentage points in protein intakes to the sons' dietary reduction.

Figure 5 presents the energy intake allocation with and without negative income shock. I use the mean of the sample and the estimates from Column 2 in Table 7 to calculate the percentage deviations of energy intakes with and without negative income shocks. The percentage deviation of energy intake from DRIs standard is labelled. The energy intakes show a 3-percentage-point increase for fathers, a 7-percentage-point decrease for sons, a 19-percentage-point decrease for daughters, and a 22-percentage-point decrease for mothers.

To interpret the results more intuitively, I convert the percentage-point of energy reduction into the rice consumption using the United States Department of Agriculture Food Composition Database. On average, a 22-percentage-point decrease in energy intake for mothers means a 166.6-gram daily reduction in cooked rice. A 19-percentage-point decrease for daughters is equivalent to a 134.7-gram rice reduction. A 7-percentage-point decrease for sons reduces rice consumption by 49.9 grams.

The estimates of Table 7 highlight the order of resource redistribution in the event of income shocks: macronutrients allocate to fathers first, sons second, daughters third, and the mothers last. Fathers, as the main bread earners of families, are likely to be supported first to ensure future income. Although it is not officially documented by the CHNS, mothers or housewives are usually the main food handlers in the family. The largest reduction in mothers are likely to be explained by the altruistic sacrifice towards their children.

Robustness check

The specifications so far assume that the negative income shock takes effects at a 25% threshold. However, Osberg (2015a) argues that the 25% cut is a rather arbitrary threshold. I, therefore, test the income loss of 20% and 30%. The results are consistent. I also test the estimation by using a continuous measure of income loss. Instead of using a binary variable of negative income shock, the proportionate income loss is used and it is defined as the following:

$$\begin{aligned} &IncomeFall_{it} = \frac{Y_{it} - Y_{it-1}}{Y_{it-1}} && \text{if } Y_{it} \leq Y_{it-1}; \\ &IncomeFall_{it} = 0 && \text{if } Y_{it} > Y_{it-1} \end{aligned} \tag{6}$$

Table 8 shows the sibling fixed effects estimates of dietary intake using the continuous measures. To be comparable with the previous estimation, it starts with simple specification and gradually adds more controls. Specification 1 controls for household characteristics. Specification 2 adds child characteristics, and Specification 3 controls for all including log equivalent income. All specifications estimate for percentage deviation of energy, carbohydrate, fat and protein intakes from the DRIs standard.

Column 1 in Table 8 shows that when income falls by one percentage point, the energy intake increases by 0.12 percentage points of the DRIs standard controlling for household characteristics. The girls' daily intake of overall energy is 0.08 percentage points lower than boys. The effects of income fall become stronger after controlling for child-specific characteristics and income. Column 3 shows that one percentage point in income fall from the previous cycle, boys increases energy intake by 0.23 percentage points. Alternatively, a one standard deviation increase in income fall leads to a 9.2% of standard deviations increase in energy intake[14]. Girls' energy intake is significantly lower than boys. For one standard deviation of income fall, girls energy intake increase by 2.9%.

Columns 3 to 12 in Table 8 break down the energy intake into types of macronutrient. The estimates of carbohydrate in three specifications show consistent positive effects from income fall as shown in row 2. *%IncomeFall* is positive, meaning the income fall increases carbohydrate intake, and *%IncomeFall*Girl* is negative, meaning the effects on carbohydrate intake is negative on girls compared to their brothers. The preferred specification of Column 6 shows that a 100% income fall increases carbohydrate intake by 42.1 percentage points for boys, and 15.3 percentage points (=0.42.1-0.268) in girls. In other words, one standard deviation decrease in income, increases carbohydrate intake by 11.3% standard deviations in boys, and 4.1% standard deviations in girls. Fat intakes are not statistically significant. Protein intake is reduced in both genders, with a larger reduction in girls. A unit of income fall leads to a reduction of protein intake by 0.255 units of for boys, and by 0.378 (=-0.255-0.123) units for girls. If the income decreases by 1 standard deviation, the protein intake would decrease by 8.9% standard deviations for boys and 13.2% standard deviations for girls.

Table 9 shows larger effects of income fall using adolescents sample. For one unit of income fall, energy intake increases by 0.386 percentage points in boys, and 0.052 percentage points in girls; carbohydrate intake increases by 0.727 percentage points in boys, and 0.194 percentage points in girls. In other words, one standard deviation in income fall increase energy intake by 14.2% standard deviations in boys, and 1.9% standard deviations

[14] It is calculated using the coefficient multiplied by the standard deviation of income fall, divided by the standard deviation of the dependent variable.

in girls, and increase carbohydrate intake by 19.0% in boys, and 5.0% in girls. Changes in fat and protein intake are insignificant in the adolescent sample.

The estimates using the percentage income fall show that children's food intake and nutrition allocation is affected by the level of income fall continuously. The average effects show that boys and girls increase the carbohydrate intake and decrease the protein intake in response to income losses. The increase in carbohydrate is less but the decrease in protein is more for girls.

I also test quadratic form of income loss. The quadratic term is not significant. Besides the sample of children with siblings of opposite sex, I examine the children with siblings of the same sex. I do not find any dietary orders or patterns within the families, such as the first-born preference.

Conclusion

This study draws the following conclusions. First, protein and fat intakes of Chinese children are significantly lower, while carbohydrate and overall energy intakes are higher, than the DRIs standard. In all four categories, girls have significantly lower intake levels than boys, suggesting a gender disparity before the negative income shocks take place. Second, in response to negative income, Chinese families tend to reduce their protein intake, the primary macronutrient, possibly due to a higher price. Third, adolescent girls experience a larger dietary reduction than boys in energy, carbohydrate, and fat intakes.

The most compelling finding is that when families experience negative income shocks, the resource is allocated in the order of fathers, sons, daughters and mothers. Gender inequality is heightened in the event of income loss. The prioritizing fathers and sons, while neglecting daughters and mothers show an increase in gender disparity in response to large income loss. It draws concerns that economic losses are likely to impede the development of daughters and obstructs the well-being of mothers.

Birch & Fisher (1998) documents that eating behaviour during childhood and adolescence can have significant influences on future food intake. Parental dietary practices can alter dietary intake patterns, preferences for energy-dense foods, and even the internal responsiveness to hunger and satiety in children and in future adulthood. The phenomenon of "feeding the little emperor" in response to negative income shocks in Chinese families is especially problematic for children's future development, and could contribute to unhealthy eating habits and adult obesity.

It is unclear that the differences in dietary intake are caused by parental control, or if it stems from the children themselves. The gender difference could come from the children themselves. Sons could be more expressive about their demands than daughters. Girls, especially adolescent girls, may be more reserved about their requests and "internalize" their demand. Also, sons may be more likely to demand food, and girls may request resources other than food (e.g. clothing or beauty products). When dealing with children's demands, parents may be more likely to give in when they are under economic stress.

One of the limitations is that I focus on families with sex-mixed children. It is also interesting to examine if father or mother would reduce more intakes in only child families. Given the presence of grandparents and their involvements in child care in China, the dietary intakes of grandparents could also be examined.

I only examine macronutrient intakes but not micronutrient intakes. Micronutrients, such as vitamins and minerals, play an important role in the healthy development of children. For future research, other dietary intakes could be examined when such data are available.

Another direction of future research is to include the price of food in the analysis. The CHNS provides detailed information on the price of rice, bread, meat, and oil in the local market. It would be interesting to examine if the negative income shock makes families opt out from expensive protein and opt in for cheap carbohydrate.

Apart from dietary intakes, it would be interesting to also examine time and consumption allocation within the household. For obesity research, for example, time spent in physical activity, TV and video games could be investigated and gender differences could be explored. The consumption patterns, such as pocket money (*Ling Hua Qian*) distribution and the frequency of western fast food restaurant visits, are also worthy of attention.

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Appendix I: Tables

Table 1: Dietary Reference Intakes (DRIs): Recommended Dietary Allowances and Adequate Macronutrients Intakes

Group	Carbohydrate (g/d)	Fat (g/d)	Protein (g/d)	Energy calorie
Infants				
0 to 6 mo	60	31	9	555.4
6 to 12 mo	95	30	11	694
Children				0
1-3y	130	30	13	842
4-8y	130	30	19	866
Males		30		270
9-13y	130	30	34	926
14-18y	130	30	52	998
19-30y	130	30	56	1014
31-50y	130	30	56	1014
51-70y	130	30	56	1014
>70y	130	30	56	1014
Females		30		270
9-13y	130	30	34	926
14-18y	130	30	46	974
19-30y	130	30	46	974
31-50y	130	30	46	974
51-70y	130	30	46	974
>70y	130	30	46	974
Pregnancy		30		270
14-18y	175	30	71	1254
19-30y	175	30	71	1254
31-50y	175	30	71	1254
Lactation		30		270
14-18y	210	30	71	1394
19-30y	210	30	71	1394
31-50y	210	30	71	1394

Source: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002/2005) and Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate (2005). The report may be accessed via www.nap.edu.

Fat intake of 1 to 70-year-old is from Dietary Reference Intakes (DRIs): Acceptable Macronutrient Distribution Ranges. The average of the range is used. Energy intake is calculated by the author using Energy(calorie)=9xFat(g)+4xCarb(g)+4xProtein(g). Energy from alcohol intake is ignored from the calculation because of lack of data. It is not likely to affects the estimation as the subject of the study is children of 2 to 17-year-old who are not likely to consume alcohol.

Table 2: Summary statistics of sibling sample of analysis

		Boy			Girl	
VARIABLES	N	Mean	SD	N	Mean	SD
Energy % dev	2,667	1.107	0.643	2,908	0.998	0.608
Carb % dev	2,667	1.529	0.919	2,908	1.387	0.848
Fat % dev	2,667	0.602	0.953	2,908	0.515	0.910
Protein % dev	2,667	0.703	0.725	2,908	0.597	0.655
Father Energy % deviation	2,488	1.693	0.726	2,699	1.696	0.736
Father Carb % deviation	2,488	2.466	1.120	2,699	2.466	1.136
Father Fat % deviation	2,488	1.088	1.162	2,699	1.102	1.197
Father Protein % deviation	2,488	0.405	0.435	2,699	0.411	0.438
Mother Energy % deviation	2,618	1.435	0.659	2,855	1.435	0.669
Mother Carb % deviation	2,618	2.070	0.988	2,855	2.063	0.996
Mother Fat % deviation	2,618	0.832	1.021	2,855	0.844	1.053
Mother Protein % deviation	2,618	0.482	0.464	2,855	0.490	0.469
%IncomeFall*Girl	2,362	0	0	2,563	0.124	0.240
%IncomeFall	2,362	0.122	0.238	2,563	0.124	0.240
NegativeShock*Girl	2,667	0	0	2,908	0.118	0.322
NegativeShock	2,667	0.114	0.318	2,908	0.118	0.322
Loss30	2,667	0.164	0.370	2,908	0.166	0.373
Loss20	2,667	0.190	0.393	2,908	0.192	0.394
Number of children	2,667	2.485	0.649	2,908	2.577	0.758
Number of extra hh members	2,667	2.453	0.813	2,908	2.461	0.846
Primary Schooling	2,667	0.313	0.464	2,908	0.338	0.473
Middle Schooling	2,667	0.175	0.380	2,908	0.220	0.414
Child at the age of puberty	2,667	0.522	0.500	2,908	0.346	0.476
Birth order	2,667	1.915	0.845	2,908	1.600	0.771
Equivalent Income	2,667	7,221	8,581	2,908	7,423	9,119
Rural residents	2,667	0.814	0.389	2,908	0.813	0.390
Number of families	1,312	1,312	1,312	1,312	1,312	1,312

Source: CHNS 1991 to 2011. Children 2 to 17 year old. Sample of children with siblings of opposite sex. At least two children in one family are surveyed in one cycle.

Note: % dev of energy, carb, fat and protein is the percentage deviation of macronutrient intake from the age- and gender-specific DRIs standards. Equivalent income is defined as household income after tax and transfer divided by square root of household size. NegShock is defined as 1 if the equivalent income falls more than 25% from the average of previous 3 cycles, 0 otherwise. Loss30, Loss25, Loss20 are defined as the income loss of 30, 25 and 20 percent from the previous cycle

Table 3: Reasons for negative income shock

	No negshock					With neg shock				
VARIABLES	N	Mean	Sd	Max	Min	N	Mean	Sd	Max	Min
Reasons for negative income shock										
Illness	2,323	0.313	0.464	1	0	272	0.346	0.476	1	0
Unemployment	5,956	0.153	0.360	1	0	688	0.173	0.378	1	0
Family dissolution	5,935	0.0136	0.116	1	0	682	0.0323	0.177	1	0
Old age	6,014	0.00449	0.0669	1	0	695	0.00288	0.0536	1	0
Channels: dietary attitude										
Diet knowledge: lot of sugar is good (1-5)	374	2.214	0.673	5	1	40	2.625	0.952	5	2
Diet knowledge: diet high in fat (1-5)	359	2.228	0.768	5	1	40	2.325	0.829	5	1
Diet knowledge: lot of staple food (1-5)	352	2.861	0.958	5	1	41	3.195	0.901	4	2
Diet knowledge: lot of animal products (1-5)	379	2.879	1.032	5	1	41	3.073	1.058	5	1
Diet knowledge: heavier body (1-5)	380	1.939	0.661	5	1	40	2.100	0.871	5	1
Number of families	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358

Note: CHNS 1991 to 2011.
Unemployment=1 if either parent changed or lost jobs since the last survey. Illness=1 if either parent has self-reported health of 1 or 2 on a 4-point scale, or self-reported hypertension, diabetes, myocardial diseases, stroke or cancer. Family dissolution=1 if either parent reports single, divorced, widowed or separated. Old age=1 if father is older than 60 or mother is older than 55.

Diet knowledge is asked for children 12 and older in cycles 2004 to 2011. 5 represents strongly agree and 1 is strongly disagree.

Table 4: Estimates of child intake with sibling fixed effects, children with siblings of opposite sex.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	Energy % dev	Energy % dev	Energy % dev	Carb % dev	Carb % dev	Carb % dev	Fat % dev	Fat % dev	Fat % dev	Protein % dev	Protein % dev	Protein % dev
NegativeShock*Girl	-0.0468	-0.0814**	-0.0754**	-0.0742*	-0.148***	-0.145***	-0.0165	-0.0108	-0.0113	-0.0967**	-0.0592	-0.0400
	(0.0319)	(0.0320)	(0.0315)	(0.0448)	(0.0411)	(0.0413)	(0.0344)	(0.0390)	(0.0393)	(0.0382)	(0.0384)	(0.0382)
NegativeShock	0.0992***	0.0335	0.0537	0.213***	0.124***	0.140***	0.0268	-0.0663	0.0304	-0.152***	-0.0608	-0.160***
	(0.0370)	(0.0383)	(0.0411)	(0.0456)	(0.0460)	(0.0503)	(0.0554)	(0.0596)	(0.0667)	(0.0432)	(0.0439)	(0.0507)
Log eq income			0.0264			0.0269			0.0864***			-0.0827***
			(0.0193)			(0.0230)			(0.0314)			(0.0229)
Observations	6,930	5,645	5,575	6,930	5,645	5,575	6,930	5,645	5,575	6,930	5,645	5,575
R-squared	0.008	0.072	0.074	0.013	0.134	0.136	0.009	0.052	0.057	0.014	0.136	0.141
Number of fixedm	1,380	1,320	1,312	1,380	1,320	1,312	1,380	1,320	1,312	1,380	1,320	1,312
HH characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child Characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Sibling fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: CHNS 1991 to 2011. Children 2 to 17 year old. Sample of children with siblings of opposite sex. At least two children in one family are surveyed in one cycle.
Note: Standard errors clustered by families in parentheses. *p<.1; **p<.05; ***p<.01.

The dependent variable is the percentage deviation of macronutrient intake from the age- and gender-specific DRIs standards. HH characteristics include number of children in the household and number of other relative and non-relatives in the household. Child characteristics include if the child has graduated from primary school or middle school, puberty onset and birth order. Log equivalent income is defined as household income after tax and transfer divided by square root of household size. Constant is included in the estimation. NegShock is defined as 1 if the equivalent income falls more than 25% from the average of previous 3 cycles, 0 otherwise.

Table 5: Estimates of child intake with sibling fixed effects, children of sex mix adolescent sample.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	Energy % dev	Energy % dev	Energy % dev	Carb % dev	Carb % dev	Carb % dev	Fat % dev	Fat % dev	Fat % dev	Protein % dev	Protein % dev	Protein % dev
NegativeShock*Girl	-0.182***	-0.211***	-0.193***	-0.239***	-0.312***	-0.294***	-0.182**	-0.201***	-0.196**	-0.0849*	-0.0188	0.000327
	(0.0601)	(0.0624)	(0.0604)	(0.0833)	(0.0839)	(0.0846)	(0.0717)	(0.0772)	(0.0774)	(0.0504)	(0.0525)	(0.0516)
NegativeShock	0.0111	0.0344	0.0924	0.135	0.160*	0.244**	-0.0835	-0.0658	0.0198	-0.110**	-0.0897*	-0.0982
	(0.0664)	(0.0661)	(0.0742)	(0.0859)	(0.0862)	(0.0963)	(0.0980)	(0.0970)	(0.114)	(0.0554)	(0.0543)	(0.0616)
Log eq income			0.0506			0.0785*			0.0555			-0.00129
			(0.0343)			(0.0447)			(0.0495)			(0.0300)
Observations	2,468	2,421	2,396	2,468	2,421	2,396	2,468	2,421	2,396	2,468	2,421	2,396
R-squared	0.021	0.029	0.030	0.026	0.049	0.051	0.018	0.023	0.024	0.025	0.101	0.098
Number of fixedm	1,076	1,060	1,052	1,076	1,060	1,052	1,076	1,060	1,052	1,076	1,060	1,052
HH characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child Characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Sibling fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: CHNS 1991 to 2011. Children 2 to 17 year old. Sample of children with siblings of opposite sex. At least two children in one family are surveyed in one cycle.
Note: Standard errors clustered by families in parentheses. *p<.1; **p<.05; ***p<.01.

The dependent variable is the percentage deviation of macronutrient intake from the age- and gender-specific DRIs standards. HH characteristics include number of children in the household and number of other relative and non-relatives in the household. Child characteristics include if the child has graduated from primary school or middle school, puberty onset and birth order. Log equivalent income is defined as household income after tax and transfer divided by square root of household size. Constant is included in the estimation. NegShock is defined as 1 if the equivalent income falls more than 25% from the average of previous 3 cycles, 0 otherwise.

Table 6: Estimates of parents' intakes with family fixed effects, parents with children of sex mix sample.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	Energy % dev	Energy % dev	Energy % dev	Carb % dev	Carb % dev	Carb % dev	Fat % dev	Fat % dev	Fat % dev	Protein % dev	Protein % dev	Protein % dev
NegativeShock*Mother	-0.289***	-0.305***	-0.285***	-0.471***	-0.498***	-0.463***	-0.270***	-0.246***	-0.246***	0.0593***	0.0332*	0.0427***
	(0.0275)	(0.0280)	(0.0272)	(0.0403)	(0.0405)	(0.0395)	(0.0307)	(0.0318)	(0.0327)	(0.0163)	(0.0170)	(0.0164)
NegativeShock	0.0402	0.0756*	0.00915	0.126**	0.191***	0.0478	0.0427	0.00945	0.0367	-0.0921***	-0.0562**	-0.0602**
	(0.0436)	(0.0425)	(0.0484)	(0.0598)	(0.0566)	(0.0648)	(0.0674)	(0.0686)	(0.0787)	(0.0262)	(0.0259)	(0.0295)
Log eq income			-0.0447**			-0.102***			0.0230			0.00253
			(0.0204)			(0.0272)			(0.0343)			(0.0134)
Constant	1.318***	2.207***	2.527***	1.830***	3.418***	4.131***	1.164***	0.614*	0.488	0.238**	0.960***	0.948***
	(0.199)	(0.232)	(0.269)	(0.271)	(0.318)	(0.368)	(0.347)	(0.353)	(0.442)	(0.115)	(0.140)	(0.166)
Observations	13,235	13,141	12,961	13,235	13,141	12,961	13,235	13,141	12,961	13,235	13,141	12,961
R-squared	0.025	0.047	0.047	0.029	0.064	0.067	0.005	0.008	0.008	0.010	0.036	0.036
Number of fixedm	1,373	1,368	1,360	1,373	1,368	1,360	1,373	1,368	1,360	1,373	1,368	1,360
HH characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Family fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: CHNS 1991 to 2011. Children 2 to 17 year old. Sample of children with siblings of opposite sex. At least two children in one family are surveyed in one cycle.
Note: Standard errors clustered by families in parentheses. *p<.1; **p<.05; ***p<.01.

The dependent variable is the percentage deviation of macronutrient intake from the age- and gender-specific DRIs standards. HH characteristics include number of children in the household and number of other relative and non-relatives in the household. Individual characteristics include levels of education. Log equivalent income is defined as household income after tax and transfer divided by square root of household size. Constant is included in the estimation. NegShock is defined as 1 if the equivalent income falls more than 25% from the average of previous 3 cycles, 0 otherwise.

Table 7: Estimates of parents' and children's intakes with family fixed effects, families with children of sex mix sample.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	Energy % dev	Energy % dev	Energy % dev	Carb % dev	Carb % dev	Carb % dev	Fat % dev	Fat % dev	Fat % dev	Protein % dev	Protein % dev	Protein % dev
NegativeShock*Girl	-0.0814**	-0.113***	-0.0963***	-0.123***	-0.175***	-0.155***	-0.0395	-0.0763**	-0.0684*	-0.103***	-0.0601*	-0.0448
	(0.0326)	(0.0320)	(0.0317)	(0.0471)	(0.0449)	(0.0456)	(0.0366)	(0.0381)	(0.0388)	(0.0373)	(0.0361)	(0.0354)
NegativeShock*Mother	0.341***	-0.140***	-0.134***	0.568***	-0.186***	-0.184***	0.242***	-0.184***	-0.173***	-0.224***	0.0441	0.0544
	(0.0355)	(0.0368)	(0.0371)	(0.0524)	(0.0537)	(0.0549)	(0.0355)	(0.0402)	(0.0411)	(0.0334)	(0.0342)	(0.0338)
NegativeShock*Father	0.633***	0.107***	0.0976**	1.043***	0.213***	0.188***	0.514***	0.0455	0.0550	-0.282***	0.0306	0.0307
	(0.0401)	(0.0404)	(0.0418)	(0.0619)	(0.0607)	(0.0629)	(0.0433)	(0.0466)	(0.0485)	(0.0346)	(0.0351)	(0.0352)
NegativeShock	-0.349***	-0.0765**	-0.175***	-0.519***	-0.0912*	-0.273***	-0.296***	-0.0420	-0.0116	0.0737*	-0.0893**	-0.137***
	(0.0374)	(0.0388)	(0.0425)	(0.0491)	(0.0510)	(0.0565)	(0.0569)	(0.0587)	(0.0664)	(0.0408)	(0.0407)	(0.0425)
Log eq income			-0.0928***			-0.179***			0.0362			-0.0420***
			(0.0185)			(0.0243)			(0.0308)			(0.0138)
Constant	1.312***	0.590***	1.484***	1.754***	0.603**	2.311***	1.230***	0.654**	0.330	0.279**	0.648***	1.052***
	(0.166)	(0.193)	(0.261)	(0.214)	(0.267)	(0.357)	(0.306)	(0.318)	(0.408)	(0.128)	(0.120)	(0.176)
Observations	20,165	18,786	18,536	20,165	18,786	18,536	20,165	18,786	18,536	20,165	18,786	18,536
R-squared	0.030	0.186	0.193	0.038	0.228	0.242	0.010	0.071	0.071	0.013	0.097	0.100
Number of fixedm	1,380	1,372	1,364	1,380	1,372	1,364	1,380	1,372	1,364	1,380	1,372	1,364
HH characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Family fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: CHNS 1991 to 2011. Children 2 to 17 year old. Sample of children with siblings of opposite sex. At least two children in one family are surveyed in one cycle.
Note: Standard errors clustered by families in parentheses. *p<.1; **p<.05; ***p<.01.

The dependent variable is the percentage deviation of macronutrient intake from the age- and gender-specific DRIs standards. HH characteristics include number of children in the household and number of other relative and non-relatives in the household. Individual characteristics include levels of education. Log equivalent income is defined as household income after tax and transfer divided by square root of household size. Constant is included in the estimation. NegShock is defined as 1 if the equivalent income falls more than 25% from the average of previous 3 cycles, 0 otherwise.

Table 8: Sibling fixed effects estimates of dietary intake on percentage income fall (continuous measure). Child with the opposite sex sibling sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	Energy % dev	Energy % dev	Energy % dev	Carb % dev	Carb % dev	Carb % dev	Fat % dev	Fat % dev	Fat % dev	Protein % dev	Protein % dev	Protein % dev
IncomeFall*Girl	-0.0797**	-0.139***	-0.162***	-0.0937*	-0.232***	-0.268***	-0.0436	-0.0279	-0.0513	-0.232***	-0.137**	-0.123**
	(0.0396)	(0.0388)	(0.0400)	(0.0564)	(0.0516)	(0.0535)	(0.0422)	(0.0489)	(0.0511)	(0.0543)	(0.0533)	(0.0541)
IncomeFall	0.120**	0.0865	0.237***	0.256***	0.229***	0.421***	0.0100	-0.0886	0.177	-0.124*	-0.0402	-0.255***
	(0.0561)	(0.0583)	(0.0774)	(0.0708)	(0.0715)	(0.0970)	(0.0789)	(0.0856)	(0.117)	(0.0665)	(0.0662)	(0.0935)
Log eq income			0.0762***			0.0983***			0.131***			-0.101***
			(0.0252)			(0.0307)			(0.0416)			(0.0312)
Observations	5,705	4,982	4,925	5,705	4,982	4,925	5,705	4,982	4,925	5,705	4,982	4,925
R-squared	0.008	0.075	0.080	0.011	0.137	0.143	0.008	0.052	0.059	0.017	0.140	0.146
Number of fixedm	1,207	1,172	1,166	1,207	1,172	1,166	1,207	1,172	1,166	1,207	1,172	1,166
HH characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child Characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Sibling fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: CHNS 1991 to 2011. Children 2 to 17 year old. Sample of children with siblings of opposite sex. At least two children in one family are surveyed in one cycle.
Note: Standard errors clustered by families in parentheses. *p<.1; **p<.05; ***p<.01.

The dependent variable is the percentage deviation of macronutrient intake from the age- and gender-specific DRIs standards. HH characteristics include number of children in the household and number of other relative and non-relatives in the household. Child characteristics include if the child has graduated from primary school or middle school, puberty onset and birth order. Log equivalent income is defined as household income after tax and transfer divided by square root of household size. Constant is included in the estimation. The %IncomeFall is defined as the percentage income fall from previous cycle using CPI adjusted household equivalent disposable income.

Table 9: Sibling fixed effects estimates of dietary intake on percentage income fall (continuous measure). Adolescents with the opposite sex sibling sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	Energy % dev	Energy % dev	Energy % dev	Carb % dev	Carb % dev	Carb % dev	Fat % dev	Fat % dev	Fat % dev	Protein % dev	Protein % dev	Protein % dev
IncomeFall*Girl	-0.279***	-0.325***	-0.334***	-0.384***	-0.512***	-0.533***	-0.193**	-0.220**	-0.239**	-0.208***	-0.0705	-0.0510
	(0.0710)	(0.0755)	(0.0790)	(0.101)	(0.105)	(0.110)	(0.0859)	(0.0932)	(0.0979)	(0.0738)	(0.0758)	(0.0774)
IncomeFall	0.0769	0.0968	0.386***	0.263**	0.291**	0.727***	-0.118	-0.110	0.131	-0.0736	-0.0667	-0.0471
	(0.0934)	(0.0937)	(0.134)	(0.124)	(0.125)	(0.169)	(0.136)	(0.137)	(0.206)	(0.0811)	(0.0771)	(0.108)
Log eq income			0.133***			0.201***			0.109			0.0130
			(0.0463)			(0.0582)			(0.0720)			(0.0398)
Constant	1.107**	1.251***	0.0234	1.275**	1.454***	-0.418	2.088***	2.189***	1.168	-0.160	-0.0897	-0.172
	(0.443)	(0.440)	(0.591)	(0.499)	(0.500)	(0.739)	(0.647)	(0.625)	(0.821)	(0.335)	(0.340)	(0.527)
Observations	2,223	2,188	2,170	2,223	2,188	2,170	2,223	2,188	2,170	2,223	2,188	2,170
R-squared	0.020	0.031	0.041	0.028	0.056	0.070	0.017	0.022	0.026	0.026	0.105	0.102
Number of fixedm	962	951	946	962	951	946	962	951	946	962	951	946
HH characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child Characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Sibling fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered by families in parentheses. *p<.1; **p<.05; ***p<.01. CHNS 1991 to 2011. Children 2 to 17 year old. Sample of adolescents with siblings of opposite sex.

Source: CHNS 1991 to 2011. Children 2 to 17 year old. Sample of children with siblings of opposite sex. At least two children in one family are surveyed in one cycle.
Note: Standard errors clustered by families in parentheses. *p<.1; **p<.05; ***p<.01.

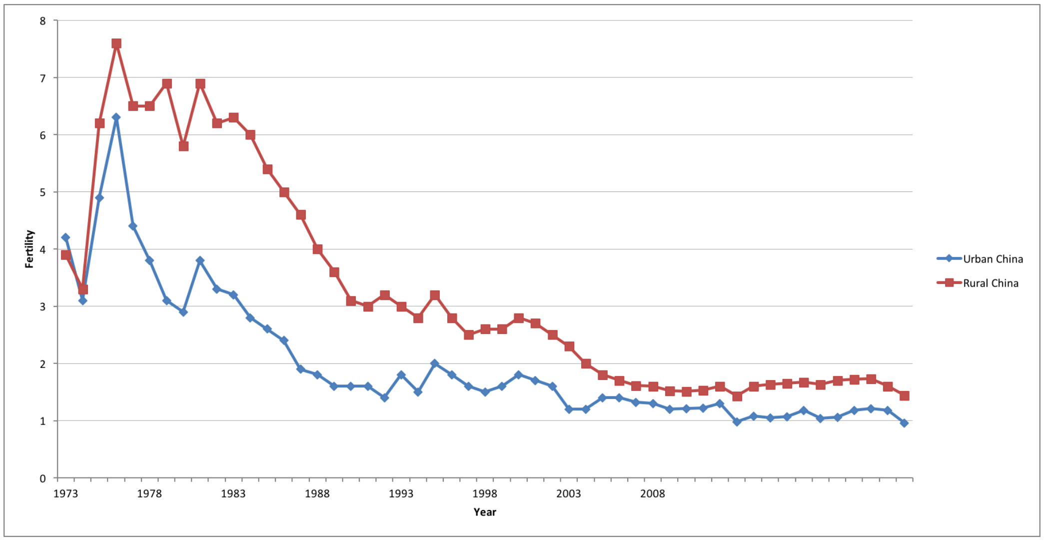
The dependent variable is the percentage deviation of macronutrient intake from the age- and gender-specific DRIs standards. HH characteristics include number of children in the household and number of other relative and non-relatives in the household. Child characteristics include if the child has graduated from primary school or middle school, puberty onset and birth order. Log equivalent income is defined as household income after tax and transfer divided by square root of household size. Constant is included in the estimation. The %IncomeFall is defined as the percentage income fall from previous cycle using CPI adjusted household equivalent disposable income.

Appendix II: Figures

Figure 1. Map of China with CHNS provinces

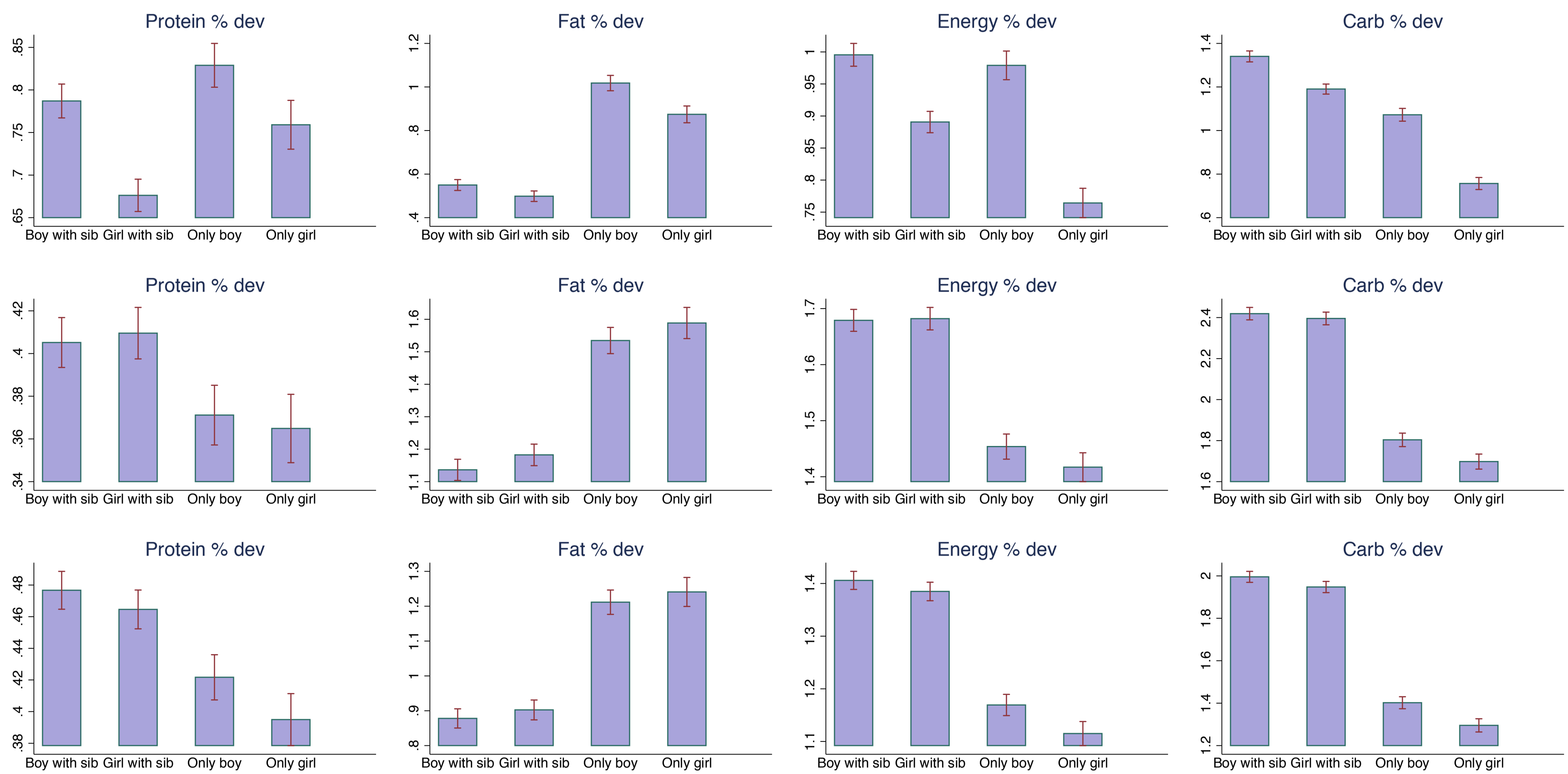
Source: *China Health and Nutrition Survey* (2017)

Figure 2. Fertility Rate for Rural and Urban China (1973-2010)



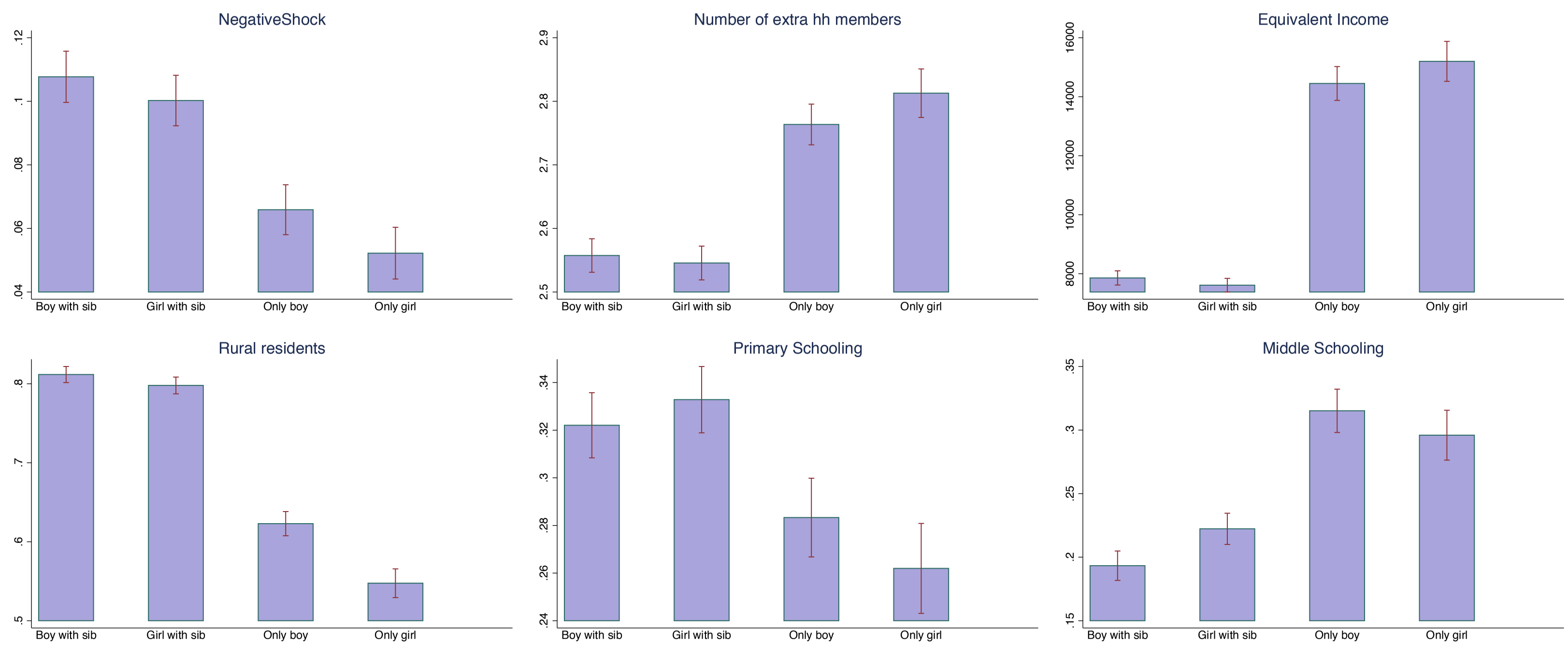
Source: The figure is reproduced based on data from Zhang (2017). It is originally compiled from Peng & Guo (2000) for 1973-1992 data; the 2001 National Fertility and Reproductive Health Survey for 1993-1999; Juan & Qiu (2011) for 2001-2009 data; and the national population censuses for 2000 and 2010 data.

Figure 3. Outcome variables by gender and single child status



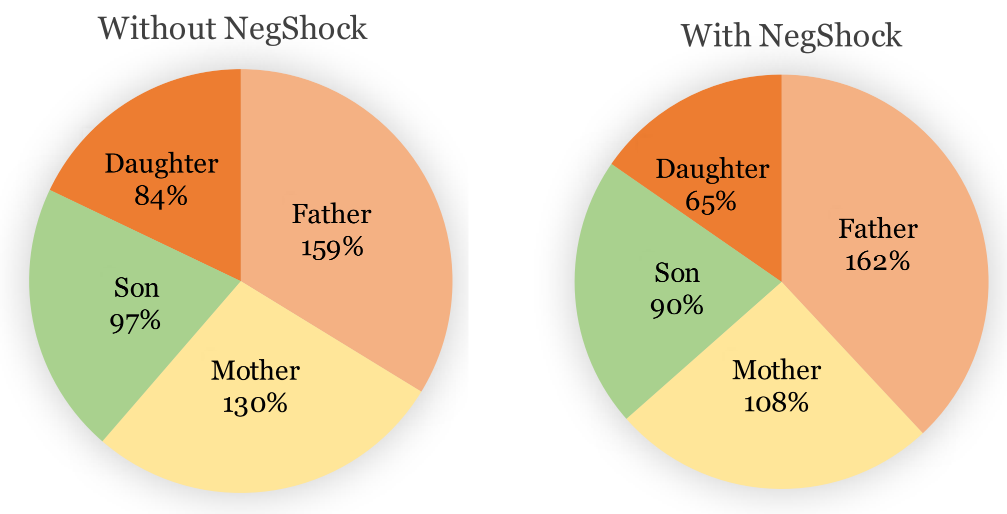
Note: CHNS 1991 to 2011. Children 2 to 17 year old. Sibling sample and single child sample. $\%Dev$ is defined as the percentage deviation of macronutrient intakes from the age- and gender-specific DRIs standards.

Figure 4. Independent variables by gender and single child status



Note: CHNS 1991 to 2011. Children 2 to 17 year old. Sibling sample and single child sample. *NegShock* is defined as 1 if the equivalent income falls more than 25% from the average of previous 3 cycles, 0 otherwise. *Number of extra hh members* is defined as household size minus two parents minus number of children (e.g. number of grandparents, relatives, and non-relatives). *Equivalent income* is defined as household income after tax and transfer divided by square root of household size.

Figure 5. Energy distribution with and without negative income shock



Source: Author's calculation. Note: The without income shock is used from the mean energy intakes of the sample. The with income shock is calculated using the estimates from Table 7 Specification 2. The percentage deviation of energy intake from DRIs standard is labelled.