Have Advances in Prenatal Sex Determination Erased the Nutritional Disadvantage for Chinese Girls?

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November 2008

Abstract

This paper investigates whether technological advances in prenatal sex determination have led to postnatal nutrient intake equality between boys and girls in China, despite an exceptionally high ratio of boys to girls at birth. Dominance methods applied to data from the Chinese Health and Nutrition Surveys (CHNS, selected years 1991 to 2004) reveal no bias in calorie consumption between girls and boys. We find a significant protein bias toward boys in 1991, but it disappears by 2004.

Keywords: gender bias; undernutrition; lower partial moments; China

JEL classification: I32; O15; N35

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1. Introduction

Modern technology for prenatal diagnostic testing, especially the ultrasound B scan, became nearly universally available in China in the 1980s, in both urban and rural areas (Chu, 2001).[1] The advanced methods dramatically improved the accuracy of prenatal sex determination over older methods, which have been part of traditional Chinese medicine for centuries. Coupled with China's one-child policy and strong son preferences, prenatal sex selection reached epidemic levels in the late 1980s, as many women opted for (legal) abortions upon discovering that the fetus was female. The prevalence of female-selective abortions raised sex ratios at birth (SRB) from 108 boys per 100 girls in 1982 to 121 boys per 100 girls in 2005 (Li, 2007). Some consequences of the new technology were harder to anticipate, much like the truism among economists that public policies often have quite unintended consequences.

In particular, we argue that the *prenatal* gender screening process – which strongly favors boys in China – reduced *postnatal* discrimination against Chinese girls. We are not the first to suggest that the recent advances in medical technology that allow parents to make prenatal sex selection decisions may also affect the postnatal well-being of girls (Banister, 2004; Echavarri, 2007). These authors note that prenatal sex selection should result in fewer unwanted girls, and therefore in declines in female infanticide and in "excess" female mortality due to neglect. Our contribution is to investigate a potential form of neglect by testing for inequality across distributions of nutrient intake for girls and boys in China, using micro data from various years between 1991 and 2004.

[1] Chu (2001) provides an historical overview of prenatal sex determination in China.

From a public choice perspective, it is noteworthy that the Chinese government, alarmed by the sharp increase in the SRB, attempted to eliminate prenatal sex selections by banning the use of ultrasound for the purpose of sex determination apart from medical reasons in 1993, and by enacting the Human Reproductive Technology Ordinance of 2000 that banned sex-selective pregnancy termination. Both efforts have been mostly fruitless, however, because of the rapid privatization and deregulation of health care in China and the widespread use of cheap mobile ultrasound machines during this period.

Independent of the prenatal sex selection issue, gender bias in development indicators such as nutrient intake has interested economists for several decades. The question here has been whether women and girls, in particular, receive fewer household resources than men and boys in developing countries, which could lead to poorer relative health and nutrition status.[2] Interest in such gender bias is unlikely to diminish, because the millennium development goals (United Nations, 2006) make eradication of extreme poverty and hunger and promotion of gender equality the first and third development goals of the new millenium. Tracking progress on meeting these goals will require methods suited to the detection of movements in the relevant indicators.

The standard approach for testing gender bias in intra-household resource allocation is to measure whether the effect of an additional son on the consumption of adults differs from the effect of additional daughter (Deaton, 1997). Few of these studies have found statistically significant evidence of gender bias, even in data collected prior to the technological advances in sex determination. However, most of these studies have to rely on expenditure data for assignable adult goods that constitute a relatively small share of expenditures.

[2] See Park and Rukumnuaykit (2004) and Dancer et al. (2008) for references to this literature.

We take an alternative approach by presenting dominance methods for monitoring gender bias in nutrient intake, using data collected in the China Health and Nutrition Surveys (1991, 1993, 1997, 2000, and 2004). We examine whether Chinese females suffer a nutritional disadvantage in calories or protein relative to Chinese males, with particular attention to comparisons of girls and boys. As shown below, we use the lower partial moments (LPM) of nutrition intake distributions, decomposed by subgroup, to make comparisons over the whole range of the distributions and for multiple years. This approach also allows us to pool data from various years and focus in on the most vulnerable girls, those from ages zero to two. Finally, to study potential nutrient substitutions, we combine calorie and protein intakes into a simple nutrient index. Our statistical procedure imposes no parametric assumptions about the distribution of intakes among subpopulations or across the whole population. It also allows inferences at any nutrition consumption target values chosen by the researcher.

2. Detecting Gender Bias using Lower Partial Moments

Our approach to comparisons of female and male nutrient intakes owes much to Kakwani (1989), who first applied dominance methods to undernutrition. The particular dominance comparisons that we make are of "lower partial moments" of distributions, decomposed by gender. In the income distribution literature, Deutsch and Silber (1999) and Butler and MacDonald (1987) show that dominance of one set of LPMs over another corresponds to the notion of "economic advantage". In this application, we refer to LPM comparisons as measures of "nutritional advantage."

To express the notion of LPMs more formally, let x be a continuous variable with a nutrient probability density $f(x)$, and let $F(x)$ represent the cumulative distribution function (CDF) of x. Let the inverse CDF of x be written $0 \le F^{-1}(p) \le \infty$ and, without loss of generality, let $\tau = F^{-1}(p)$ define target nutrient levels. When p = 0.1, 0.2, …, 1.0, the target nutrient levels become the decile order statistics. Let I_τ^x be an indicator variable such that $I_\tau^x = 1$ if $x \le \tau$ and $I_\tau^x = 0$ otherwise.

Given a target nutrient level τ, we can define the *h*-th partial moment for $x < \tau$ of the density function $f(x)$ as

(1) $$M(\tau; h, x) = \int_0^\tau x^h f(x)dx = \int_0^\infty (xI_\tau^x)^h dF(x) = E\left[(xI_\tau^x)^h\right],$$

where *E* is the expectation operator. Following Butler and McDonald (1987), we define the normalized incomplete moment of x for $x \le \tau$ as

(2) $$\phi(\tau, h, x) = M(\tau, h, x) / E(x^h),$$

When $h = 1$, for instance, the normalized incomplete moment yields the Lorenz ordinates, $\varphi(\tau,1,x) = L(\tau; x)$. In this case, to represent population subgroups, let nutrient status be classified by *K* mutually exclusive groups $\{\Phi_k, k = 1,2,.., K\}$ and define an indicator variable G_k^x such that $G_k^x = 1$ if $x \in \Phi_k$ and $G_k^x = 0$ otherwise. This indicator variable allows us to rewrite $\varphi(\tau,1,x)$, because $E(xI_\tau^x | G_k^x = 1) = E(xG_k^x I_\tau^x)/E(G_k^x)$ and $E(x|G_k^x = 1) = E(xG_k^x)/E(G_k^x)$. Bishop, Chow, and Zeager (2003) use this approach to show that $\varphi(\tau,1,x)$ can be decomposed by $\varphi(\tau,1,x^{(k)})$ for k = 1, 2, …, K in that

(3) $$\varphi(\tau,1,x)=\sum_{k=1}^{K}P^{(k)}\varphi(\tau,1,x^{(k)}),$$

where $P^{(k)} = E[xG_k^x]/E(x)$. We can interpret $P^{(k)}$ as the nutrient share of subgroup *k* with respect to the nutrient variable *x*.

Bishop et al. (2003) present a detailed description of the formal inference tests for the differences of these partial moments over different distributions. We implement these tests to provide statistical inferences for the dominance results in this paper. In particular, our dominance tests compare $\varphi(\tau,h,x^{(1)})$ to $\varphi(\tau,h,x^{(2)})$, with the "disadvantaged group" having a large fraction of its population below the target than the "advantaged group." We select fractions of the Recommended Dietary Allowances (RDAs) as our target nutrient levels. The RDAs are based on the principle that most, if not all, individuals of a population or a specific population group should obtain an adequate nutrient intake to satisfy their daily requirements. We focus on the case of h = 0 by simply counting the cumulative number of persons below some fraction of the RDA. In contrast, when h = 1 we would compare the cumulative RDA-equivalent nutrients consumed by all persons below a given fraction of the RDA.

3. Application to China

The data for our study come from the China Health and Nutrition Survey (CHNS), conducted by the Carolina Population Center. For our analysis we use the samples from 1991, 1993, 1997, 2000, and 2004.[3] While the CHNS survey was taken in 1989, children were excluded. For the later years, the CHNS is a nationally representative sample from nine regionally-dispersed provinces. The original panel includes 4,400

[3] See Liu (2009) for a complete discussion of the CHNS data.

households with over 16,000 individuals. Our main focus is on children between the ages of zero and 13, with adults ages 18 to 49 as the comparison group. We also provide some pooled results for the most vulnerable group of girls, whose ages were zero to two. In this paper, we use a set of age and gender-specific RDAs sanctioned by the Chinese Nutrition Society (2000). For each specific age and gender group, recommended energy allowances, i.e. calorie intake, represent the *average* needs of individuals. In contrast, recommended protein allowances are high enough to meet an upper level of requirement variability among individuals within the groups.

Table 1 presents descriptive statistics for our samples. It shows that in 1991 the average girl received 97 percent of her RDA for calories, while the average boy received 96 percent of his RDA, so we find no child gender calorie bias at the means of the calorie samples. Also, in 1991 the average women received 110 percent of her RDA for calories and the average man received 111 percent of his RDA, so we find no adult gender bias at the means of the calorie samples. For protein, boys appear to have some advantage over girls (84 percent of the RDA vs. 79 percent of the RDA in 1991) and men appear to have some advantage over women (105 percent vs. 103 percent of RDA in 1991). Shifting to 2004, we again find no evidence of gender discrimination for either children or adults at the calorie consumption means, but we find a significant decline in calorie consumption at the sample means over time, from 110-111 percent in 1991 to 93-94 percent in 2004. This finding is consistent with other studies (e.g., Du et. al., 2004 and Meng et. al., 2004) that report falling nutrition levels over time, usually attributed to rising food prices in China. Indeed, we find declining calorie and protein adequacy for all age groups.

While Table 1 provides interesting insights into gender differences in nutrition, differences in the means may fail to capture important differences in the full distributions. As the previous section showed, constructing the LPMs allows us to uncover any differences in the nutrient distributions for the subgroups and to make corresponding statistical inferences. Table 2 presents the point estimates of the LPMs for calories and protein. As indicated above, we normalize by RDAs to make the comparisons of nutrient intakes across gender and age meaningful.

In Table 2a we evaluate the RDA-adjusted calorie distribution at seven pre-selected fractions of the RDA for h = 0.[4] The table entries are the proportions of persons below the preset fractions of the RDA. For example, if we set the cutoff at three-quarters of the RDA (0.75) we find that 24.5 percent of the girls and 24.8 percent of the boys lie below this nutritional standard in 1991. To test the hypothesis of equivalent RDA-adjusted distributions of calories, we compare the test statistics at all seven fractions of the RDA. Column 3 provides these test statistics for the girl-boy comparison in 1991. As none of the seven test statistics is greater than 1.96, we can conclude that there is no significant difference in the calorie consumption of boys and girls in 1991. Column 9 reports the corresponding statistics for the 2004 comparison. Again, we find no significant difference in the calorie consumption of boys and girls.

Table 2b presents the RDA-adjusted protein distributions for both children and adults. We find that in 1991 (columns 1 and 2) 49.9 percent of girls and 42.7 percent of boys have protein intakes below the three-quarters of the RDA. The value of the test statistics for this comparison is 2.30, implying that boys enjoy a statistically significant protein advantage over girls in 1991 with respect to this target level of distribution.

[4] We also used 7 population percentiles with little difference in results.

Examining column 9, the 2004 test statistics, we find that none is greater than 1.96. Therefore, the boy protein advantage in 1991 disappears by 2004.

Table 3 summarizes the dominance results presented in Table 2 and provides additional results from alternative samples of the CHNS. For all years examined, there are no significant differences (NSD) uncovered in boy and girl calorie consumption. For protein, boys have an advantage in 1991 and 1997. However, it may be the case that girls are substituting calories for protein. To test this hypothesis, Table 3 introduces a "nutrition index," which is an equally-weighted average of RDA-normalized calories and protein. Using the nutrition index, we find no significant difference between the nutrient intakes of boys and girls in all five years examined, providing support for the substitution hypothesis.

Some researchers believe that the strongest boy bias should be observed in the first two to three years, because female infanticide – by direct action or by neglect – is rare after age three (Banister, 2004). To test this hypothesis, we pool the five years of CHNS data for ages zero to two. Table 4 provides summary statistics and dominance results from the pooled sample, which includes data from all available years. While baby boys have a higher "Protein/RDA" ratio (0.754 vs. 0.732), baby girls have a higher "Calories/RDA" ratio (0.816 vs. 0.797). The nutrition index values for baby boys and baby girls, which take both nutrition measures into consideration, are almost exactly the same. Moreover, we find no significant difference in any of the dominance comparisons in Table 4. Overall, these findings suggest that baby boys and baby girls have nearly identical access to nutrition, with some modest substitution of calories for protein among baby girls.

We also tested for the sensitivity of our conclusions to our choices of h = 0 and the preselected targets. While changing the h value and the targets can have some minor changes in our findings, it does not change our overall conclusion of little or no boy bias in nutrition.

4. Conclusions

We argue that an “unintended consequence” of improved sex selection technology in China is reduced postnatal gender discrimination against girls. We use data from the Chinese Household Nutrition Survey to test for gender bias in nutrition in China, focusing particularly on girls and boys (ages 0-13) in selected years from 1991 to 2004. We find no gender bias in calorie consumption for any of the years examined. We find some bias toward boys in protein consumption in 1991, but we cannot detect such a bias in 2004. Moreover, females substitute calories for protein, thus alleviating, in part, the protein bias. For children at the most vulnerable ages (0-2), we find no significant difference in either of calorie or protein distribution by gender. These findings are consistent with a reduction in discrimination, due to a decline in unwanted children, as the technology for sex selection improves.

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Table 1. Sample Means for Calories and Protein by Age and Gender

	Girls	***Boys***	***Women***	***Men***
Calories (kcal) in 1991	1685	1781	2548	2970
Calories (kcal) in 2004	1493	1575	2154	2521
Calories/RDA in 1991	0.97	0.96	1.10	1.11
Calories/RDA in 2004	0.82	0.82	0.94	0.93
Protein (g) in 1991	47.9	51.0	71.9	84.0
Protein (g) in 2004	51.5	54.8	63.6	74.8
Protein/RDA in 1991	0.79	0.84	1.03	1.05
Protein/RDA in 2004	0.71	0.76	0.91	0.94

Note: Children are ages 0-13, Adults ages 18-49.

Table 2a. Subgroup Lorenz Ordinates by Gender and Age: Calories, 1991 and 2004

Percent of RDA	1991						2004					
	Girls (1)	Boys (2)	z-score (3)	Women (4)	Men (5)	z-score (6)	Girls (7)	Boys (8)	z-score (9)	Women (10)	Men (11)	z-score (12)
0.50	0.033	0.038	0.64	0.00	0.00	0.00	0.110	0.139	1.45	0.037	0.039	0.33
0.75	0.245	0.248	0.15	0.082	0.084	0.28	0.449	0.479	0.67	0.267	0.259	-0.56
0.90	0.464	0.465	0.06	0.246	0.248	0.19	0.683	0.673	-0.16	0.500	0.490	-0.44
1.00	0.598	0.602	0.13	0.394	0.419	1.43	0.780	0.786	-0.12	0.639	0.647	-0.31
1.10	0.722	0.730	0.21	0.549	0.578	1.35	0.860	0.858	-0.14	0.765	0.780	0.47
1.25	0.848	0.852	0.08	0.739	0.757	0.70	0.925	0.915	-0.14	0.881	0.891	0.31
1.50	0.941	0.951	0.19	0.907	0.909	0.07	0.980	0.963	-0.22	0.955	0.962	0.21
Sample Size	1484	1680	-	3496	3272	-	644	704	-	2758	2577	-

Note: Boys and girls are ages 0-13, Adults ages 18-49.

Table 2b. Subgroup Lorenz Ordinates by Gender and Age: Protein, 1991 and 2004

Percent of RDA	1991						2004					
	Girls (1)	Boys (2)	z-score (3)	Women (4)	Men (5)	z-score (6)	Girls (7)	Boys (8)	z-score (9)	Women (10)	Men (11)	z-score (12)
0.50	0.120	0.097	-1.81	0.009	0.009	0.00	0.259	0.251	-0.25	0.073	0.059	-1.80
0.75	0.499	0.427	-2.30	0.170	0.156	-1.29	0.624	0.574	-0.90	0.332	0.305	-1.51
0.90	0.711	0.650	-1.50	0.390	0.367	-1.34	0.803	0.726	-1.15	0.555	0.518	-1.47
1.00	0.804	0.764	-0.91	0.543	0.522	-0.99	0.859	0.794	-0.92	0.675	0.648	-0.95
1.10	0.871	0.836	-0.74	0.668	0.650	-0.73	0.904	0.869	-0.47	0.777	0.747	-0.97
1.25	0.930	0.911	-0.38	0.806	0.784	-0.76	0.961	0.928	-0.44	0.865	0.858	-0.22
1.50	0.977	0.974	-0.06	0.922	0.909	-0.40	0.984	0.970	-0.18	0.947	0.940	-0.18
Sample Size	1484	1680	-	3496	3272	-	644	704	-	2758	2577	-

Note: Boys and girls are ages 0-13, Adults ages 18-49.

Table 3: Dominance Results for Boys and Girls by Year

Year	Nutrient Distributions: Calories	Nutrient Distributions: Protein	Nutrient Index	Sample Sizes (#boys, #girls)
1991	NSD	0.75	NSD	1680, 1484
1993	NSD	NSD	NSD	1333, 1504
1997	NSD	0.75	NSD	1128, 1279
2000	NSD	0.95	NSD	999, 1143
2004	NSD	NSD	NSD	644, 704

Note: 0.75 or 0.95 denotes boys dominating girls at these fractions of the RDA. NSD means "no significant difference".

Table 4: Summary Statistics and Dominance Results for Ages 0-2 in the Pooled Sample

	Baby Girls	Baby Boys
Calories	915	934
Calories/RDA	0.816	0.797
Protein	28.1	28.9
Protein/RDA	0.732	0.754
Nutrition Index	0.774	0.776
Sample Size	374	413
Calorie Dominance?	NSD	
Protein Dominance?	NSD	
Nutrition Dominance?	NSD	

Note: The pooled sample includes data from 1991, 1993, 1997, 2000 and 2004. Babies are defined as 0 – 2 years of age. Raising the top age in this category to 3, 4 or 5 does not alter the dominance results. NSD means "no significant difference".