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An Assessment Of China's Fertility Level Using The Variable-*r* Method

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ABSTRACT

The current fertility level in China is a matter of uncertainty and controversy. This paper applies Preston and Coale's (1982) variable-*r* method to assess the fertility level in China. Using data from China's 1990 and 2000 censuses, and annual population sample surveys, the variable-*r* method confirms that Chinese fertility has indeed reached a level well below replacement.

AN ASSESSMENT OF CHINA'S FERTILITY LEVEL USING THE VARIABLE-*r* METHOD

INTRODUCTION

The current fertility level in China is a matter of considerable controversy (Guo 2003; Ratherford et al. 2005; Zhang 2004, 2005). The total fertility rate (TFR) reported in China's 1990 census was 2.3. According to later surveys, it dropped below replacement level[1] in 1991 and has stayed at around 1.5 ever since, with a low of 1.22 reported in the 2000 census. A TFR of 1.5 is not only far below replacement, it is among the lowest national rates in the world. Many regard China's reported fertility as too low to be true and attribute it to the deterioration of the Chinese statistical system, claiming a large number of births, particularly out-of-plan births, are underreported in official enumerations.

This paper applies Preston and Coale's (1982) variable-*r* method to assess China's fertility level. The variable-*r* method offers a simple and robust estimate of the net reproduction rate (NRR). Unlike traditional fertility estimation methods, which often require detailed birth records, the variable-*r* method requires only the relative age distribution in two enumerations and the proportional birth distribution, both of which are readily available for China.

We begin with a brief overview of the debate over the current fertility level in China, followed by a discussion of the variable-*r* method. Because the application of the variable-*r* method requires that the data from two enumerations have the same

[1] Around 2.1-2.2 at China's current mortality level and sex ratio at birth.

completeness of coverage, a significant proportion of this paper is devoted to assessing whether there were major changes in enumeration coverage between the 1990 and 2000 censuses. Using census and annual population survey data, we find that the 1990 and 2000 censuses data are comparable in coverage. The variable-*r* is thus appropriate for use. It confirms that Chinese fertility has indeed reached a level well below replacement.

WHAT IS THE CURRENT FERTILITY LEVEL IN CHINA

The fertility transition in China began in the early 1970s. TFR dropped by more than half in 10 years, from 5.8 in 1970 to 2.7 in 1979 (Coale and Chen 1987; Yao 1995). This was a great success of China's "*later, sparser, and fewer*" program (Scharping 2003). In the 1980s, even with a much more restrictive one-child policy, fertility continued to oscillate around 2.5 (Feeney and Wang 1993). Then there was a sudden drop in the early 1990s. The 1992 fertility survey reported total fertility of 1.65 in 1991 and 1.52 in 1992, a great departure from what reported in the 1990 census – a TFR of 2.3. The fertility level stayed around 1.5 in the 1990s. The 2000 census recorded a new low of 1.22. The 2002 and 2003 annual population change surveys reported TFRs at 1.39 and 1.41. The fertility trend in China since 1970 is portrayed in Figure 1.

[Figure 1 about here]

Both the sharp drop in fertility and the very low level attained after 1990 raised suspicions of underreporting (Feeney and Yuan 1994; Goodkind 2004; Liang 2003; Zeng 1996). The suspicions were grounded on four significant circumstances.

First, data evaluations indicate that a considerable proportion of births and children do go uncounted in Chinese censuses and surveys. For example, Feeney and Yuan (1994) found that the 1992 fertility survey missed between 10 and 20% of births. A comparison of 1990 census and 2000 census data yields an estimate that 13.68% of the age 0 population was not enumerated in the 1990 census (Zhang and Cui 2003).

Second, the reported fertility level is close to or even lower than the level implied by policy. Birth planning policy is fragmented by local administrations and tailored to local conditions (Peng 1991). Guo et al. (2003) have estimated that perfect implementation of these local policies would imply a national TFR of around 1.47. Fertility at or below this level implies a perfect execution of the policy, which contradicts the general impression of difficulties in policy implementation and numerous reports of local resistance and policy breaches.

Third, the low fertility rates reported in China is at odds with the experience of other counties. While the socioeconomic transformation of the post-Mao era has greatly improved living standards, China is still largely a developing county with very limited social welfare programs. It is thus expectable that Chinese, particular those living in rural areas, would continue to have at least moderate fertility demands in order to continue the family line and secure old age support.

Fourth, despite the consistency of public reports of low fertility, the Chinese government itself is very reluctant to accept them as fact. The government still cites a total fertility rate of 1.8, below replacement level but higher than reported in surveys. Official estimates are presumably backed by data yet to be disclosed.

Virtually every demographer agrees that underreporting exists in China's population and fertility data. Underreporting is neither a new nor a uniquely Chinese phenomenon (Anderson 2004). The debate is over the level of underreporting and how reported fertility should be adjusted. Efforts to estimate the fertility level in China have concentrated on “recovering” uncounted births with various techniques, such as reverse-projection using aggregate data and birth history reconstruction using household records (e.g. Ding 2003; Guo 2003; Retherford et al. 2005; Zhang 2005; Zhang and Cui 2003). Preston and Coale’s (1982) variable-*r* method provides an alternative.

THE VARIABLE-*r* METHOD

As an extension of the generalized stable population model, the period net reproduction rate (NRR) can be expressed as a function of age-specific growth rates and the proportionate age distribution of mothers at childbirth (Preston and Coale 1982). In Equation 1, $\upsilon(a)$ denotes the proportionate age distribution of mothers at childbirth, $r(x)$ denotes the age specific growth rate, and α and β specify the beginning and end of women’s reproductive age range, assumed to be 15 and 49. Estimation of NRR in this way constitutes the variable-*r* method.

$$NRR = \int_{\alpha}^{\beta} \upsilon(a) e^{\int_0^a r(x)dx} da \qquad (1)$$

The beauty of the variable-*r* method is its simplicity and robustness. It captures the net reproduction rate “without any reference to underlying fertility or mortality” (Preston, Heuveline and Guillot 2001:176). Both $\upsilon(a)$ and $r(x)$ can be easily estimated from censuses and surveys. Applications of this method yield very robust results. For example, estimates using Swedish data from 1973 to 1977 produced an error of less than 1% in each year compared to the NRR computed from age-specific fertility and mortality rates (Preston and Coale 1982). Using Japanese data between 1995 and 2000, the variable-*r* method produces exactly the same value of NRR as the traditional method (Preston et al. 2001).

Apart from simplicity and robustness, an attractive feature of the variable-*r* method is its relaxed data requirements. The success of traditional methods for fertility estimation relies on the accuracy of enumeration (or adjustment) of births and women in the reproductive ages. The variable-*r* method relaxes data requirements in several respects. First, the population age structure required by the variable-*r* method is the relative age distribution, i.e. the age specific growth rate. This is less sensitive to distortion than the true age structure. Even in the event of substantial underreporting, if two enumerations had similar rates of underreporting, the fertility estimate yielded by the variable-*r* method would be the same as if there were no underreporting. Second, instead of focusing on the birth cohort, the variable-*r* method makes use of the full age distribution from birth to the end of reproduction, thus providing a more stable measure of fertility. This is not only because the use of the full age distribution smoothes out irregularities in individual ages, but also because data quality is better in ages beyond the infant and child ages, particularly in Chinese census data. Third, the variable-*r* method only uses the age structure of females, which is less sensitive to the enumeration of the military population.

The variable-*r* method produces a reproductive measure that is central to the concept of replacement fertility. NRR measures the number of daughters that a hypothetical cohort of newborn baby girls would have during their lifetime. It implicitly takes mortality and the sex ratio of births into account. An NRR of 1.0 means that a female population subjected to set fertility and mortality schedules would exactly reproduce/replace itself. The NRR is thus essential to the idea of replacement-level fertility. By contrast, the evaluation of replacement level fertility using the TFR needs to take the mortality level and the sex ratio at birth explicitly into account. This would be a particular problem in the Chinese context, where rising sex ratios at birth and gender-biased mortality (Cai and Lavely 2003) would make the comparison of fertility to the replacement level sensitive to assumptions about mortality and sex-selective behaviors.

NRR is the sum of the product of the maternity function *m(a)* and the survival function *p(a)* (Equation 2). The maternity function is the age-specific fertility rate of female births. NRR can be converted to TFR using a well-known approximation shown in Equation 3, in which SRB is the sex ratio at birth (males per one female) and $p(\overline{m})$ is the probability of surviving to the mean age of the maternity function (Preston and Coale 1982). We will use Equation 3 to compare NRR with the more commonly used TFR.

$$NRR = \int_{\alpha}^{\beta} m(a)\,p(a)\,da \qquad (2)$$

$$TFR = \frac{(1+SRB)\cdot NRR}{p(\overline{m})} \qquad (3)$$

Like any other demographic method, even with its more relaxed data requirements, the variable-*r* method is still sensitive to data quality, particularly the data quality at young ages. Although the growth rate is calculated for each age group, the growth rates for younger age groups have a disproportional effect on the fertility estimate because the effect of growth is cumulative. As Preston and Coale (1982:248) point out, the variable-*r* method is mainly subject to two kinds of reporting errors: from changes in the patterns of age misreporting and from differences in completeness of coverage. Age misreporting is less a problem for Chinese data, as has been shown by various demographic exercises (Coale 1984; Coale and Banister 1994; Banister and Hill 2004). We will consider in detail whether there is a difference in coverage across Chinese censuses.

The data required for estimating NRR by the variable-*r* method are readily available from Chinese censuses and surveys. Both censuses and annual population surveys include population enumerations, and births by women's age in the prior year.[2] Following the steps laid out in Preston et al. (2001), we use the calculation of NRR between 1990 and 2000 as an example to explain the mechanics. Other NRR estimates will be carried out following the same procedure.

As shown in Equation 1, we need the age-specific growth rates and the proportional births distribution among women of reproductive age to use the variable-*r* method. The integration in Equation 1 is approximated by summation of variables calculated for 5-year age groups as shown in Table 1. Given the population data from the 1990 and 2000 censuses, the growth rate is calculated as $r(x)=ln({}_5P_x^{2000}/\,{}_5P_x^{1990})/10.33$ (column 4) – the denominator is not an integer because these two censuses used different standard times. The growth rate is then cumulated to the mid-point of each age group and the exponential is taken (column 5). To calculate the proportionate distribution of births among women in the reproductive ages, we first gather all the births by mother's age reported in the interval from the 1991-1999 surveys and the 2000 census (column 3) and divide them by the total number of births (column 6). We derive the NRR by summing up

[2] Because the age-specific birth data from the annual population sample surveys are not available for years of 1991-1993 in the *China Population Statistics Yearbook*, we use the age specific fertility data from the 1992 fertility survey and the age structure of women from the annual population sample surveys to derive the number of births by age group for these 3 years.

the multiplication of the exponentiated cumulative age-specific growth rate with the proportional births distribution (column 7).

[Table 1 about here]

The variable-*r* method estimates a NRR of 0.698 between the 1990 and 2000 censuses, which is 30% below the replacement level. This calculation assumes that the 1990 and 2000 censuses have similar coverage. In light of the suspected problem of underenumeration, this assumption needs to be critically evaluated.

UNDERREPORTING IN THE 1990 AND 2000 CENSUSES

Chinese Population Data

Following the success of the 1982 census, China established a statistical system consisting of decennial censuses in the years ending in 0, one percent population sample surveys (mini-censuses) in years ending in 5, and one per thousand population change surveys in all other years. Both the censuses and surveys include population enumerations and fertility and mortality information for the prior year. The 1982 and 1990 census' standard time was July 1st; the 2000 census' standard time was Nov 1st. The population surveys take place in October, with the standard time set at Oct 1st. All sample survey data used here have been adjusted by the sample fractions.

Population data from China were once praised for their high quality (Coale 1984). Data accuracy benefited from the fact that Chinese have good knowledge of their date of birth, from the household registration system, and from a relatively immobile population. Some of the conditions favorable for accurate enumeration have faded with the rise of migration and pressure to meet birth planning quotas. However, the underenumeration problem in Chinese census data should not be exaggerated. Figure 1 shows the survival of female cohorts enumerated in the 1982, 1990 and 2000 census and corresponding life table survival ratios.[3] Except for a few age groups, most noticeably the age 0-4 cohort in the 1982 census, the three enumerations accord well with the mortality schedules. This not only confirms the good quality of the 1982 and 1990 census data, but also relieves some concerns about the quality of the 2000 census data.

[Figure 2 about here]

As indicated in Figure 1, the youngest cohorts were underenumerated in the 1982 census. The same was repeated in the 1990 census and very likely in the 2000 census as well. This is precisely the reason why many suspect that fertility rates were underreported. As is often noted, the main reason behind the underenumeration of infants and children in China is the pressure from the birth planning policy. Births, particular out-of-plan births, are underreported not only because parents seek to avoid penalties or to retain the possibility of having another child, but also because of strong incentives embedded in China's bureaucratic institutions. Local government officials are routinely evaluated based on a set of population control targets such as the birth rate and the one-child rate, as well as economic performance indices that are based on population size (e.g. per-capita GDP). Meanwhile, population enumeration in China is still largely founded on the household registration system (Lavely 2003). The linkage between birth quotas and permission for household registration creates a major obstacle to accurate enumeration

[3] The life table survival ratios between 1982 and 1990 are based on the 1982 census female life table; the life table survival ratios between 1982 and 2000 are based on the 1990 census female life table.

since persons lacking an official registration are often missed by enumerators. Migration further complicates the enumeration process because most migrations are not recorded in the household registration system.

Patterns of Infant and Child Under-enumeration in Chinese Population Data

The general assumption is that under-enumeration is more severe in young ages because small children are more easily hidden from public observation. As children grow up and are more integrated into society, they are more likely to be registered and more likely to be visible to enumerators. To assess the under-enumeration pattern of infants and children in Chinese population data, we utilize the age distribution enumerated in two censuses (1990 and 2000) and 11 population surveys (1991-1999 and 2001-2002) to calculate the survival ratio of each cohort between the initial enumeration and later enumerations. Appropriate adjustments have been made to later enumerations to reflect the sample proportion and to synchronize cohorts.

In Figure 3, the survival ratios of four female birth cohorts born 1987-1990 are traced from their first enumeration to the most recent population survey, along with a reference survival ratio based on the female 1990 life table. Except for the 1990 cohort's enumeration in 1991, every enumeration reported a survival ratio above 1, a clear sign of underreporting in the first enumeration. However, the most important pattern revealed by Figure 2 is that the underenumerated children were quickly recovered in the subsequent enumerations. This is obvious despite the random fluctuation from enumeration to enumeration due to the sparseness of the one per thousand sample data. The enumeration of each cohort reaches a stable size at around school age, which is likely to approximate the true cohort size. Comparing the stabilized cohort size to the size enumerated at age 0, the overall underreporting rate is between 10-20%.

Figure 3 supports the general understanding of underreporting patterns in China. Just as the comparison of the 1982, 1990 and 2000 censuses shows, the underreporting rate is highest at youngest ages and become less and less significant as age goes up. In other words, underenumeration is most severe in the youngest age group and later enumerations are likely to pick up those underreported in the prior enumerations.

[Figure 3 about here]

For the application of variable-*r* method, the problem is not underenumeration per se; rather it is whether there was a change in the underenumeration pattern between censuses. Given that there were no major changes in the motives and reasons for underreporting in China, namely, the concealment of out-of-plan births, there is no reason to expect that the underreporting pattern of 2000 would differ from that of 1990. A thorough evaluation of the completeness of the 2000 census data must wait the 2010 census. In lieu of that, we trace the enumeration pattern in the 1990s to see if major shifts in the pattern are observed.

Figure 4 traces the birth cohorts of 1990-1995 from the earliest enumeration to the most recent enumeration, along with a reference survival ratio derived from the 1990 female life table. Compared to Figure 3, we see one major change: for every cohort, the population size enumerated at age 1 is always the smallest. The discrepancy between the age 0 enumeration and the age 1 enumeration gradually increases from about 3% for the 1990 cohort to almost 20% for the 1994 cohort. Beyond age 1, the cohort size gradually recovers in the subsequent enumerations (ages) and stabilizes at around school age. The difference between the lowest and the highest enumerations is again between 10 and 20%.

[Figure 4 about here]

Figure 5 traces the birth cohorts of 1996-2001 from their earliest enumeration to the most recent enumeration, along with a reference survival ratio derived from the 1990 female life table. Similar to the pattern observed in Figure 4, the size of the age 1 enumeration is much smaller than the size of the age 0 enumeration of the same cohort. Except for the 2000 census, in which the size of the 1999 cohort is about 10% smaller than that enumerated in 1999, all other cohorts' size was about 20% smaller in the second enumeration than in the first enumeration. Again, beyond age 1, every subsequent enumeration recovered some of those underenumerated at age 1; but the cohort size never reaches the size enumerated at age 0. Although we do not have data to trace the cohort further, in light of the enumeration patterns from the previous cohorts, we expect that the enumerated size of the 1996-2000 cohorts would stabilize at around school age.

[Figure 5 about here]

For every cohort since 1990, there is a peculiar pattern of a larger enumerated size at age 0 than at age 1. One might suppose that this is because we are using the annual population survey data, and the National Bureau of Statistics may have inflated the age 0 population size in order to report a more reasonable fertility level. However, the same pattern is also observed in the census-based 1990 and 2000 cohorts, although at a more moderate scale, and we know of no adjustments made to the census enumerations. A smaller size in age 1 for these two cohorts would imply downward adjustments of the same cohorts enumerated in the 1991 and 2001 population sample surveys, which makes no sense. Whatever the cause may be, the consistency between the population size enumerated at age 0 and the size enumerated around school age indicates that age 0 population reported in the late 1990s and in the 2000 census is probably closer to the true cohort size, while the population at age 1 has the highest underreporting rate.[4]

Apart from the peculiarity of age 0 and age 1 enumerations, the underreporting pattern in Figures 4 and 5 is very similar to that observed in Figure 3: later enumerations gradually pick up children underenumerated in earlier ones, and the initial underreporting rate is around 10-20%. In other words, although Figures 3, 4 and 5 suggest somewhat different enumeration patterns in Chinese population data in the 1990 and 2000 censuses, there is no indication that the underenumeration problem worsened in the 1990s.

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[4] A possible explanation to this peculiar phenomenon is the administrative emphasis on accurately counting the number of births in the Chinese population enumerations, in conjunction with Chinese tradition of age counting. There is no age 0 in traditional Chinese age counting; Chinese count age 1 at birth. When the emphasis is on counting the age 0 population, the process may be biased towards counting age 1 infants as age 0. Another possible explanation is policy related. To ensure enumeration quality, the government often issues assurances that the census data or population survey data will not be used as an evaluation of birth policy implementation. Some may interpret this as an official amnesty for out-of-quota births and move some of them into the age 0 category. The above two explanations are speculative and backed by no empirical evidence.

School Enrollment Data: Contrary Evidence?

The most important evidence contrary to the above assessment is the enrollment data collected by the Ministry of Education of China. In China, the official school age is 6. Normally, new enrollments would be expected to be smaller than the size of the six year old cohort in the same year because the enrollment rate is less than 100%. However, the enrollment data compiled by the Ministry of Education consistently reports new enrollments in primary school greater than the corresponding cohort size. Based on this, Zhang and Cui (2003) estimated an underreporting rate of 19% for age 4-9 in the 2000 census, which is much higher than the underenumeration of age 4-9 in the 1990 census.

The enrollment data requires some clarification. Although Chinese law stipulates age six as the official school age, a considerable proportion of children enroll in school at later ages (Zhang 2005). The expansion of educational opportunity is a fairly recent phenomenon. The proportion of children age 6-9 never enrolled in school declined from 44% in the 1982 census to 24% in the 1990 census, and to 6% in the 2000 census. The fact that the 2000 census took place two months after the start of the school year contributed to the high enrollment rate reported in the 2000 census.[5] Given the shrinking cohort sizes in the late 1990s, even a small shift in enrollment age would lead to a considerable change in the corresponding enrollment figure. For example, one-year[6] shift

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[5] The school year starts on September 1st in China. The 1982 and 1990 censuses took place in the summer, two months before the start of the school year.

[6] If the majority of children enrolled in school at the required age, there should be a good correlation between the enrollment data and population data. The correlation is .907

would cut a third from Cui and Zhang's underenumeration rate of age 4-9, from 19% to 13%.

The above comparison assumes that enrollment data are of good quality. However, there is no reason to believe that enrollment data is of better quality than the census data. As with birth rates and economic performance indices, school enrollment rates are part of local officials' performance evaluation criteria and are tied to tax revenue allocations. There are thus ample incentives to over-report enrollment. There are also plentiful opportunities to do so. Unlike the census and annual population sample survey, which is carried out by an independent agency, school enrollment data are administrative records complied by the local educational apparatus. The data are then tabulated and reported upwards through the bureaucratic hierarchy before reaching the Ministry of Education. Given the decay of Chinese statistical reporting system and the notorious manipulation of local statistics, we should not accept the enrollment data from the Ministry of Education uncritically. Table 2 compares new primary school enrollment data from 1977 to 2003 to the corresponding cohort sizes estimated from the 2000 censuses. The enrollment is almost always larger than corresponding cohort size, suggesting over-reporting in the enrollment data.

[Table 2 about here]

To summarize, there is no evidence to suggest that the quality of enumeration declined between the 1990 and 2000 censuses. Our data evaluation confirms the general understanding of the underenumeration problem in Chinese population data. The

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between the enrollment data and the age six population. However the correlation is even higher (.981) if we assume the primary school age was seven.

underreporting is more severe for infants and young children but enumeration improves as children grow up, reaching stability around school age. School enrollment data are an unreliable standard for the evaluation of the census data.

RESULTS

Given the demonstrated qualities of Chinese census data, the variable-*r* method can appropriately be used to estimate Chinese fertility. The variable-*r* method yields a NRR of 0.698 between 1990 and 2000 censuses, 30% below replacement.

To compare the estimated fertility level to more commonly used TFR, we use Equation 3 to approximate TFR from the estimated NRR. The approximation is affected by the assumed values of sex ratio at birth (SRB) and the probability for surviving to the mean age of reproduction ($p(\overline{m})$). Given China's current mortality level and the mean age of childbearing, the variation in the mean age at reproduction would have only minimal effect on the approximation. The probability of a female surviving from birth to the mean age of childbearing is about 95%. However, different assumptions about the sex ratio at birth would have a substantial effect on the approximation. The approximated TFR corresponding to the estimated NRR is 1.51 if we take a normal sex ratio at birth of 1.05, and 1.65 if we take a high sex ratio at birth of 1.25. The true sex ratio at birth in China during the 1990s is likely between these two "extreme" values. Taking the average of reported sex ratio at birth in the period of 1.15, the approximated TFR corresponding to the estimated NRR is 1.58, which is higher than the average annual TFR (1.48) reported in the surveys and census and higher than the estimated TFR (1.49) derived from summing all births and women of reproductive age from 1991 to 2000 together.

There are some concerns that certain adult age groups were over-counted and other groups were under-counted in the 2000 census (Zhang and Cui 2003). These discrepancies have only minuscule effects on the estimation of NRR using the variable-*r* method. If we adjust the population size of 2000 census at age 20 and above based on the 1990 census enumeration, the estimated NRR goes virtually unchanged from 0.698 to 0.699.

As shown in Figure 5, the cohorts born after 1996 always have the largest size in the first enumeration (at age 0). Substituting the cohort size of their first enumeration for cohorts of age 0-4 in the 2000 census increases the estimated NRR from 0.698 to 0.746. This is an estimate of fertility on the high end, but still 25% below replacement. The corresponding TFR value is 1.69 if we take the average sex ratio at birth in the 1990s.

The above calculations have not taken the declining trend of fertility into account. Although the age structure from censuses and sample surveys are not directly comparable because of sample bias,[7] nevertheless, the application of the variable-*r* method using the 1995 1% annual survey data confirms a declining trend: NRR declined from 0.734 between 1990 and 1995 to 0.658 between 1995 and 2000.

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[7] The sample survey, unlike the census that involves a massive cross-regional household registration check, tends to miss people on the move. When sample data are used to infer the national total, underenumeration of one group will be compensated automatically by over-adjustment of other age groups, because the sample is adjusted by single sample fraction. Similar sample bias also affected the 2000 census long form data. While the overall sample rate of the female population is about 9.6%, the sample rate for age around 20 was only 8.8%, and 9.7% for most other ages.

The estimated NRR indicates that the fertility in China between 1990 and 2000 censuses is about 25-30% below replacement level. Interpreting it with more commonly used measure TFR, the overall fertility in the 1990s is about 1.6 children, with a range of 1.5-1.7. This estimate is in line with the estimates presented by Guo (2004), Retherford et al. (2005) and Zhang (2005), but lower than the official adjustments. The fact that estimates based on different data and methods produce similar results supports the conclusion that fertility in China has indeed reached a level well below replacement.

DISCUSSION

China underwent a transition from high to replacement-level fertility in just two decades. By the 1990s, China's fertility was well below replacement. This dramatic decline was first initiated by the government's "*later, sparser and fewer*" program in the early 1970s and further intensified by the controversial one-child policy in the 1980s.

This tight control of fertility has come at a heavy price. Many negative consequences of the policy, anticipated and unanticipated, are materializing. Policy implementation has soaked up huge economic, social, and political resources, inflicted uncounted costs on individual families, and created high tension between citizens and government. A two-decade rise in sex ratios of births and children has reached alarming levels that are just beginning to distort marriage markets. Very low fertility has undermined traditional family supports for the aged while hastening the aging of the population, before the establishment of welfare systems for the elderly. These liabilities of the one-child policy have stimulated discussions of whether, when and how China should change its population policy (Wang 2005; Winkler 2002). One source of resistance to policy change has been the fear that the fertility rate in China is significantly underreported. Now we know with considerable certainty that the China's fertility is indeed below replacement. In other words, China has achieved the demographic conditions that permit a reevaluation of its fertility policy and a revision of its long term population strategy.

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TABLES

Table 1 Computing NRR Using the Variable-*r* Method, China 1990-2000

Age x	$_5P_x(1990)$ million (1)	$_5P_x(2000)$ million (2)	$_5B_x$ million (3)	$_5r_x$ (4)	$\exp(S_x)$ (5)	$_5v_x$ (6)	$_5r_x*\exp(S_x)$ (7)
0	55.4	31.3		-0.0551	0.8712		
5	47.7	41.8		-0.0127	0.7354		
10	47.0	60.1		0.0236	0.7558		
15	58.5	50.2	3.7	-0.0149	0.7724	0.0222	0.017
20	61.5	46.6	74.5	-0.0268	0.6959	0.4502	0.313
25	50.8	57.4	69.2	0.0119	0.6703	0.4185	0.281
30	40.2	62.0	14.4	0.0419	0.7668	0.0868	0.067
35	41.8	53.0	2.8	0.0230	0.9020	0.0171	0.015
40	30.4	39.0	0.6	0.0242	1.0151	0.0039	0.004
45	23.2	41.6	0.2	0.0563	1.2414	0.0012	0.001
Sum			165.4			1.0000	NRR= 0.698

Source: 1990 and 2000 censuses, 1991-1999 population sample surveys.

Note: $_5P_x$ – Population in 5 year age group

$_5B_x$ – Number of births to woman in 5 year age group

$_5r_x = \ln({}_5P_x^{2000} / {}_5P_x^{1990})/10.33$ – Growth Rate in each 5 year age group

S_x – Cumulation of $_5r_x$ to midpoint of interval

$_5\upsilon_x = {}_5B_x / (\sum {}_5B_x)$

$NRR = \sum {}_5r_x \cdot \exp(S_x)$

Table 2 Comparison of Yearly (1977-2003) New Primary School Enrollments and Corresponding Cohort Sizes Estimated from the 2000 Census

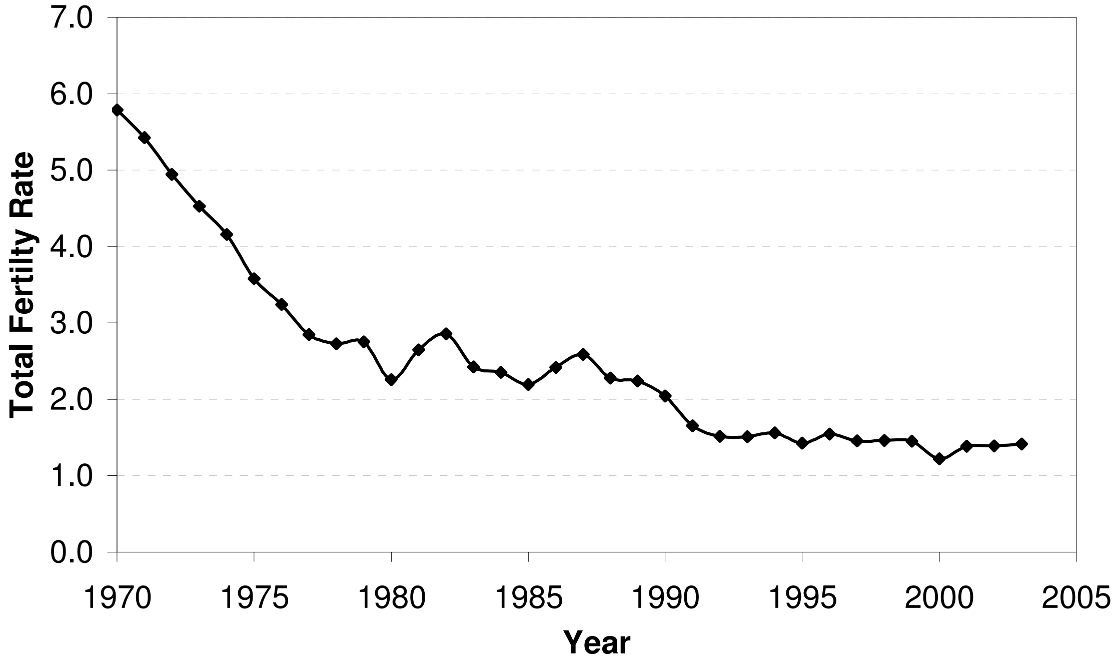
Year	New Primary School Enrollment	Cohort Size at Age 6 Estimated from 2000	Difference between Enrollment and Census Cohort Size
2003	18.3	14.4	3.9
2002	19.5	15.2	4.3
2001	19.4	16.9	2.5
2000	19.5	16.5	3.0
1999	20.3	17.9	2.4
1998	22.0	18.8	3.2
1997	24.6	20.1	4.5
1996	25.2	26.3	-1.0
1995	25.3	25.2	0.1
1994	25.4	24.7	0.7
1993	23.5	26.4	-2.9
1992	21.8	23.3	-1.5
1991	20.7	20.5	0.2
1990	20.6	20.4	0.2
1989	21.5	20.2	1.3
1988	21.2	23.3	-2.1
1987	20.9	19.3	1.6
1986	22.6	18.6	4.0
1985	23.0	19.1	3.8
1984	24.7	19.1	5.6
1983	25.4	18.3	7.1
1982	26.7	20.8	5.9
1981	27.5	21.5	6.0
1980	29.4	23.3	6.1
1979	31.0	24.1	6.9
1978	33.2	25.3	7.8
1977	31.1	25.9	5.2

unit: million

Source: School Enrollment data: *China Population Statistics Yearbook 1996*, *China Statistical Yearbook 2004*. Cohort size estimation is based on 2000 census enumeration adjusted by the 1990 census life table (Huang and Liu 1995).

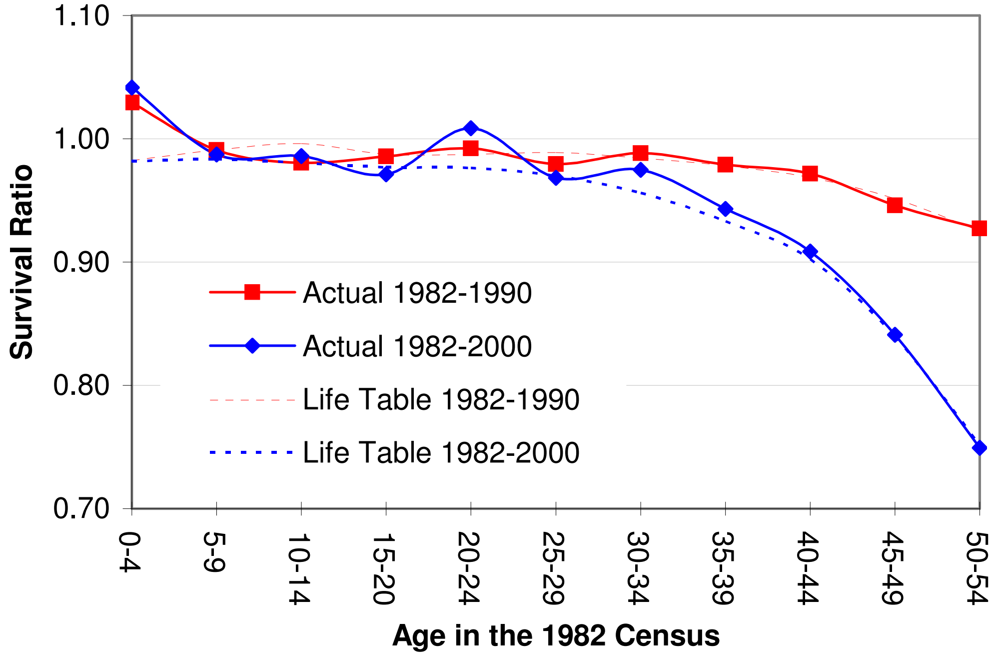
FIGURES

Figure 1 Total Fertility Rate: China 1970-2003



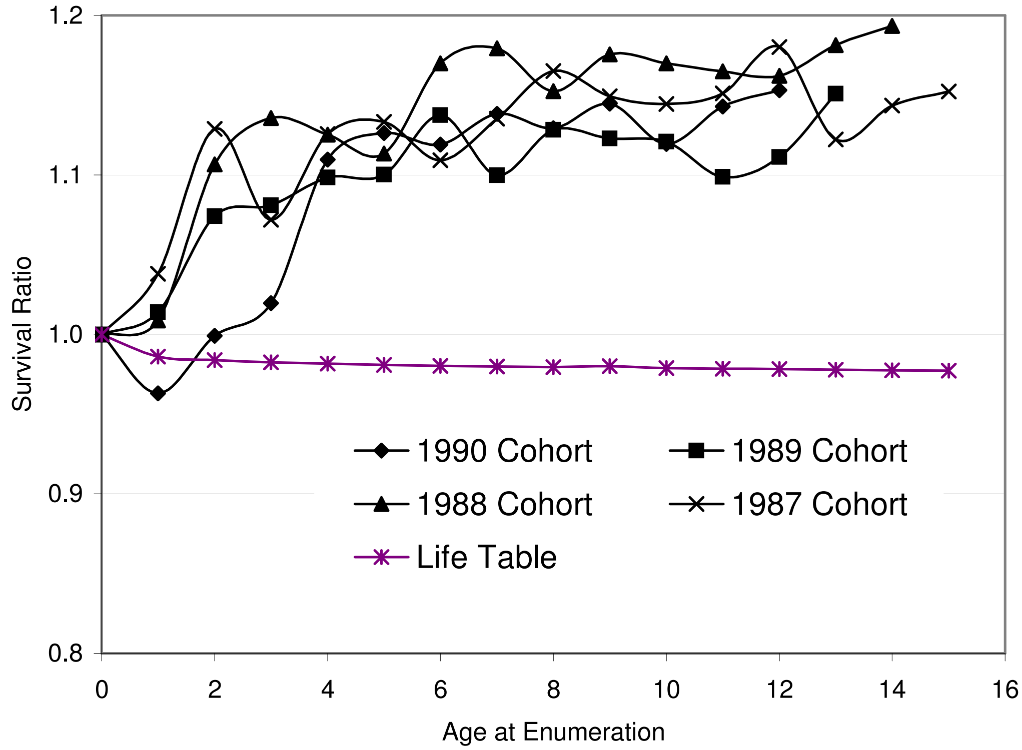
Source: 1970-1992 from Yao 1995, 1993 from 1997 Fertility Survey, 1994-2003 from Annual Population Change Survey/Census.

Figure 2 Inter-censual Cohort Survival Ratios, China 1982, 1990 and 2000



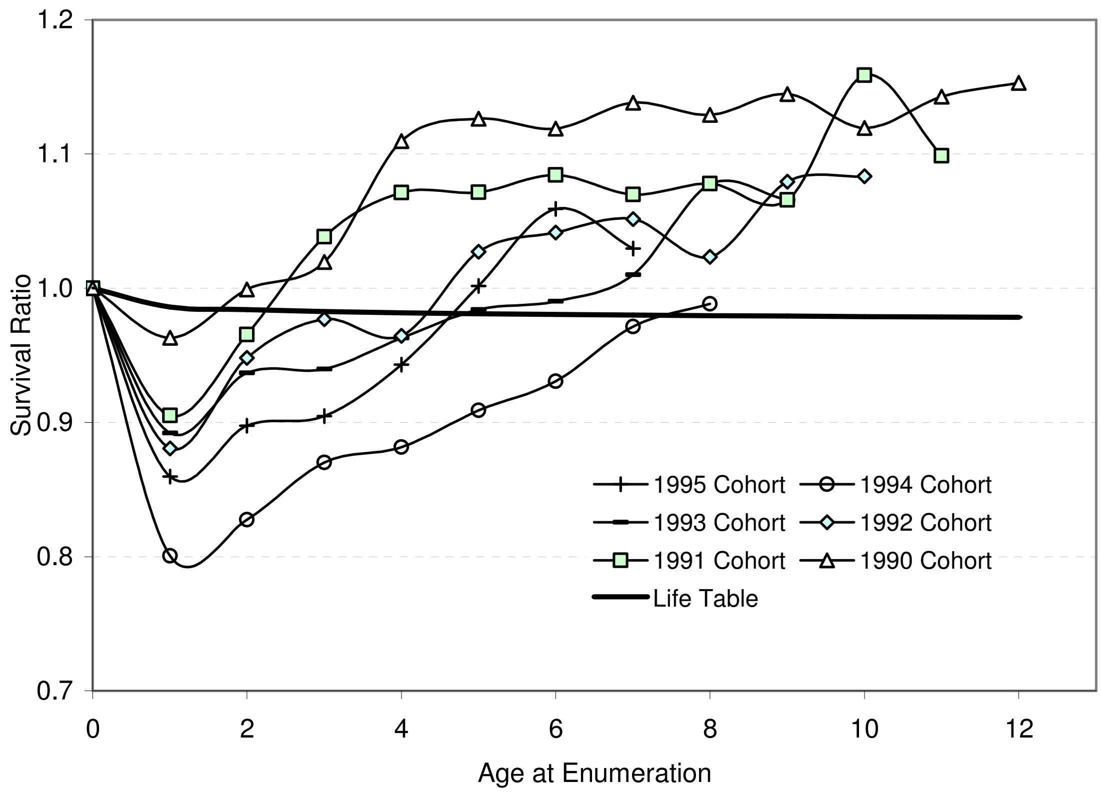
Source: 1982, 1990 and 2000 censuses, 1982 and 1990 female life tables (Huang and Liu 1995).

Figure 3 Survival Ratios of Four Female Cohorts Born 1987-1990 in Successive Enumerations



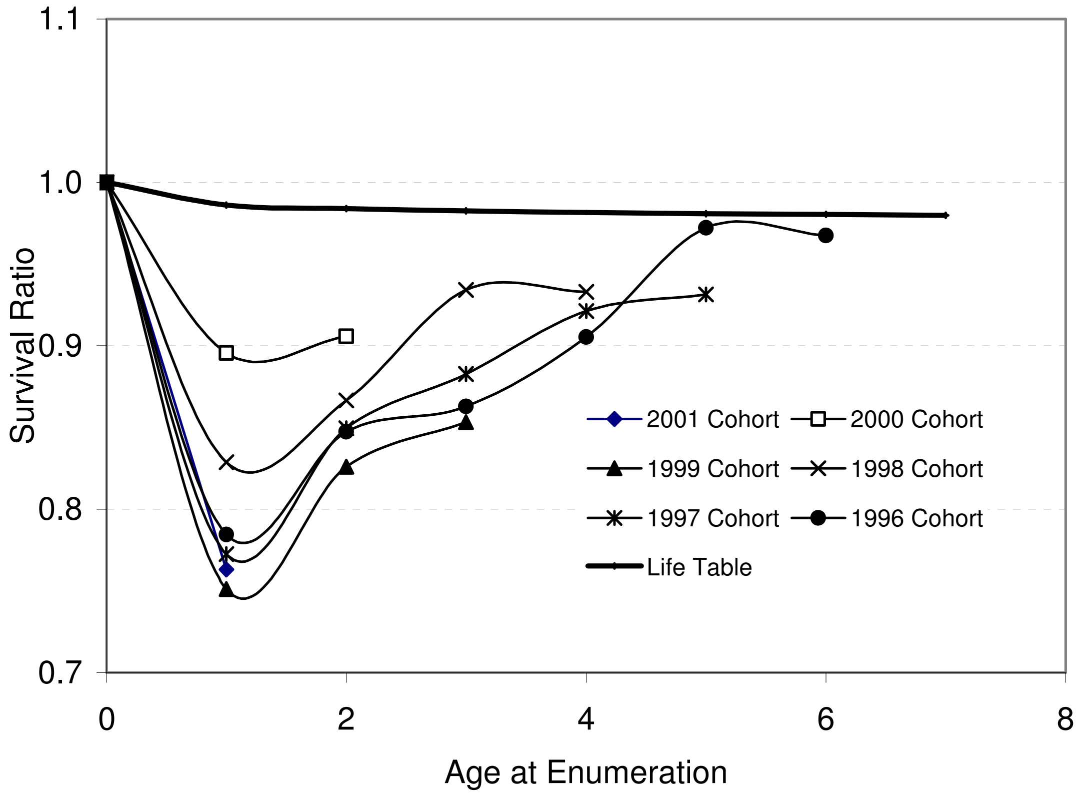
Source: 1990 and 2000 censuses, 1991-1999, 2001-2002 annual population sample surveys, and 1990 female life table (Huang and Liu 1995).

Figure 4 Survival Ratios of 1990-1995 Birth Cohorts in Successive Enumerations



Source: 1990 and 2000 censuses, 1991-1999, 2001-2002 annual population sample surveys, and 1990 female life table (Huang and Liu 1995).

Figure 5 Survival Ratios of 1996-2001 Birth Cohorts in Successive Enumerations



Source: 2000 censuses, 1996-1999, 2001-2002 annual population sample surveys, and 1990 female life table (Huang and Liu 1995).