INDIA'S CHANGING DATES WITH REPLACEMENT FERTILITY: A REVIEW OF RECENT FERTILITY TRENDS AND FUTURE PROSPECTS

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INTRODUCTION

In 1952, India became the first country in the World to launch a family planning programme aimed at reducing population growth. But since then, as one keen observer had aptly put it, it has been "a saga of great expectations and poor performance" (Srinivasan, 1998). The overly optimistic demographic goals that have been set in various planned documents and policy statements have been continuously put off to the extent that such statements now fail to enthuse anyone. Spurred by the unprecedented growth of population recorded by the 1961 Census, a goal of reaching a crude birth rate of 25 per 1,000 in 1972 was set. This goal has not been attained even by 2002. Since the 1980s, it has become a practice to set goals in terms of net reproduction rate (NRR). Accordingly in 1981, the goal of reaching NRR of one was set for the year 2000. In plan documents this goal was postponed to 2006-11 in the mid 1980s, and further to 2011-16 in the beginning of 1990s. Interestingly, the National Population Policy announced in 2000, perhaps to underscore the renewed commitment to population stabilization, had advanced the date to the year 2010!

In the meanwhile, the Sample Registration System – India's main source of information on vital rates - shows that fertility levels have indeed fallen since 1971, even though the decline is occurring at a much slower pace than what is anticipated. According to this source, total fertility rate has fallen from 5.1 in 1971-73 to 3.2 in 1996-98. There are possibilities that the actual pace of decline was somewhat faster than that suggested by this source, because over the years, completeness of birth reports under the system has probably improved. The objective of this paper is to review the current levels and trends in fertility and to suggest when India is likely to reach the replacement level fertility. I will also briefly discuss the factors contributing to the current fall, and speculate on the chances of Indian fertility falling below replacement.

RECENT LEVELS AND TRENDS IN FERTILITY

From an application of the general growth-balanced method, I have shown that during 1981-91, the SRS was underestimating adult mortality by about 8-9 per cent, and the birth rate by about 7 per cent (see Bhat 2002a). This conclusion is supported by a recent application of the own-children method to the data from the two rounds of the National Family Heath Survey (Retherford and Mishra, 2001). This analysis showed that the level of general fertility rate was higher than the corresponding SRS estimate by 9.6 per cent during 1978-92 (i.e., 15 period before the first NFHS in 1992-93) and 6.8 per cent during 1984-98 (i.e., 15-year period before the second NFHS in 1998-99). An important implication of this result is that SRS-based TFRs are on a lower side, but they underestimate the pace of fertility decline in India.

A similar conclusion emerges from the analysis of preliminary results of the 2001 Census. By reverse surviving the population age 0-6 years in 2001 (by using the child mortality rates from the SRS) I have estimated the crude birth rate during the 7-year period preceding census. These crude birth rate estimates were converted to estimates of TFR using the their ratios from the SRS.

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Table 1 shows these estimates of TFR along with similarly estimated TFRs from the 1981 and 1991 Censuses for the major states of India. The census-based estimates of TFR tend to be slightly lower than the estimates from the SRS for the corresponding periods. This is expected because of the under enumeration of child population in the census. But interestingly, they show a faster reduction in total fertility than the SRS. Thus, at the all-India level, the implied percentage fall in fertility is 15 per cent during 1977-87 against the SRS estimate of 11 per cent, and 22 per cent during 1987-97 instead of 19 per cent from the SRS.

MIDDLE LEVEL STAGNATION OR ACCELERATION?

Does fertility decline tend to accelerate or slow down at the middle of the transition? This is an important question that one must attempt to answer while making population projections. There can be two antithetical views on this. From the innovation-diffusion perspective, fertility decline should accelerate at the middle because it is assumed that decline occurs as a result of social interaction of the adopters with the non-adopters. At the beginning, as adopters of innovation are few, transition occurs at a slow pace; the pace also slows down at the end as potential adopters become few. On the other hand, it can be argued that total fertility can be brought down fairly quickly from a level say over 6 to a level near 3-4 because many had that many births only because of high mortality levels. But bringing total fertility drown from 3-4 to a level near 2 could prove difficult because it requires changes in desired family size, which can be achieved only through significant social transformation and a change in gender relations. This is especially so in India where there is a strong son preference, and generally, the desire was to have at least two sons and a daughter. Therefore this question can only be answered empirically.

As has been already pointed out, the percentage fall in TFR was higher during 1987-97 than during 1977-87. The estimates of TFR estimates from both SRS and the Censuses suggest the acceleration in the in the rate fall (see table 1). Figure 1 shows a plot of the state-level estimates of the change in the TFRs as estimated from the NFHS (between 1978-92 and 1984-98) and the Censuses of 1981 and 1991 (for 1984-90 and 1994-00) against the level of TFR (at the middle of the respective time periods). The plot shows that change in TFR has a curvilinear relationship with the level of TFR. The change in TFR is generally high when TFR is around 3-4 births per woman. This suggests that fertility decline accelerates at the middle level as predicted by the diffusion model of fertility change. A Gompertz curve was fitted in its differential form to this data (see Appendix for details). It provided a reasonably good fit (R^2=0.37). The fitted curve suggested 1.7 and 7 as lower and upper limits to TFR, with the point of inflection at 3.7. An attempt was also made to fit a logistic curve to the data (in the differential form) but it did not perform as well as the Gompertz curve (see figure 1). In particular, it suggested 1.2 as the lower limit to TFR.

Encouraged by this result that Gompertz curve describes well the changes in fertility, an attempt was made to fit the Gompertz curve to the annual time trend in TFR for every major state. Specifically, the following curve was fitted:

$$y_t = \frac{TFR_t - \alpha}{\sigma} = a^{b^t} \quad 0<a<1 \text{ and } b>1.$$

where α is the minimum value of TFR (lower asymptote), σ is the difference between the lower and upper asymptotes of TFR, a is the lag parameter that shows the value of y when time t = 0 (but must necessarily be less than 1), and b is the parameter that measures the speed of fall.

The model was fitted through linear regression using the double-log form of the model (see

Appendix). But for two states, Bihar and West Bengal, data on TFR were available from 1971. To guard against the changing completeness of SRS affecting the results, two time dummies for 1971-81 and 1982-93 were also included in the regression. Also, the regressions were done using data for the entire available time range, 1971 to 1998, as well as using data for only the more recent period of 1982-98. However, in order to make the estimates of parameter a comparable, in both the cases, the time variable t was initialized at 1951. Figure 2 shows how the model fits to the data in case of Uttar Pradesh, the largest state of India. Table 2 shows the results of the regressions for all-India (rural and urban areas separately) and major states. With respect to the completeness of births, the estimated coefficients of the relevant dummy variables suggest that compared to the period 1994-98, underreporting was 9 and 5 per cent more during 1971-81 and 1982-93, respectively. The suggested levels of incompleteness of SRS births are surprisingly close to that indicated by others sources (see Bhat, 2002a).

However, the key result in table 2 is with respect to the estimate of model parameter b, which measures the speed of fertility decline. Surprisingly, it shows little geographical variation. Except for a somewhat faster fertility decline in Kerala, the decline in north and south India appears to be occurring at about the same pace. We obtain this result in spite of making the assumption that fertility began to fall from a higher level in north India than in south India (a difference of 0.5 births in s has been assumed and, other things remaining the same, higher the assumed s, lower will be estimate of b). The lower fertility in south India is largely attributable to lower values of a, which implies earlier lowering of fertility. To illustrate this result, table 2 shows the year when TFR was 90 per cent of the maximum. According to the fitted model, if this level had been reached before the 1960s in south Indian states, it was attained only in the 1970s in the large north Indian states of Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh. A caveat in this analysis is that the Gompterz model does not allow for the possibility of some rise in fertility before the 1970s as a result of mortality decline. Nonetheless, the post-1970 patterns of fertility decline suggest that fertility is currently lower in south India because the decline began earlier there, and perhaps from a level lower than in north India.

CAUSES OF FERTILITY DECLINE

In demographic literature, rising levels of education, especially of women, is widely regarded as the major factor in fertility decline (see Diamond *et al.* 1999 for a recent review). In the case of Indian fertility transition too, the paramount role of female education has been argued forcefully in recent years by Dreze and Murthi (2001). But in a recent paper, I have argued that fertility is declining in India primarily because of its decline among illiterate women, and they are doing so because of the diffusion of a new reproductive idea of having only a few children but investing more on their future (Bhat, 2002b). It has been contended that fertility decline is not only outpacing educational transition, but also contributing to it. Through a decomposition of the change in fertility differentials by education, it has been shown that more than half of the recent fertility decline is due to its decline among illiterate women (see table 3). The rise in female education accounted for less than 20 per cent of the overall change. The contribution of this factor to the increase in contraception is estimated to be even less, 10-15 per cent only (see table 4). It has been further shown that a quantity-quality trade off is occurring as illiterate women are accepting contraception. They are observed to send more of their children to school, especially the first-born daughter, who perhaps gets released of the burden of taking care of younger siblings. It was found that the odds of sending children to school is about 50 per cent higher among illiterate women who are using contraception compared to those who do not.

Thus given the possibility that fertility levels can have significant impact on the education of children, a simple, macro-level analysis of the relationship between and female education and fertility could be misleading. Before claiming the preeminence of female education, it would be necessary to analyze how much of the correlation is because of the effect of mother's educational level on her fertility, and how much of it is derived from the effect of mother's fertility on child schooling. In my considered judgment, during the early phase of the transition, the first effect dominates while the second effect takes over in the later phases of the transition when illiterate women begin to accept contraception in large numbers.

Perhaps rising levels of aspiration for material well-being is prompting illiterate couples give precedence to quality over quantity in reproductive matters. The occurrence of this trade-off is probably aided by easier access to contraception, and increased exposure to mass media. On the latter, wherever it has been included in the analysis of fertility or use of contraception (not all do!), it has shown strong independent effects (Bhat, 1996; Ramesh and others, 1996).

LIKELIHOOD OF BELOW-REPLACEMENT FERTILITY

According to the SRS, there were at least two major states in India, Kerala (1.8) and Tamil Nadu (2.0) with below-replacement fertility in 1998. The recent NFHS results suggest some underestimation of fertility in the SRS in these states (Retherford and Mishra, 2001), though my own analysis for 1981-91 did not suggest this (Bhat, 2002a). Whatever may be truth in this regard, there is a real possibility that the *period* TFR would fall below-replacement level in many states, even though the desired family size has not fallen below two children anywhere. This is because female age first marriage in India is still below 20 years (IIPS and ORC Macro, 2000). It is unlikely that it would continue to remain at such low levels. Owing to the tempo effect, as age at marriage rises, period fertility rates would fall even if the cohort fertility remains unaltered. As population projections are generally based on period TFRs, it would be correct to assume the prevalence of below-replacement fertility for some time. But will the period fertility rise once the tempo effect ceases? The following two considerations are relevant in the context: First, many regions in India are experiencing substantial declines in fertility without concomitant increase in work participation of women. For example, in urban India, TFR is close to replacement level but less than one-third of women are in the labour force. The cessation of population growth in working ages (expected in 20-25 years) could be expected to provide an opportunity for women to enter the labour force. This could reduce further the desired family size and thus the cohort fertility. Second, with over one billion people, India already considers itself overpopulated; before NRR reaches one, it is expected to add at least another 300-400 million to its fold. With population growth rate well above one per cent at this stage, India could still be viewing its huge population as a liability. Seeing a virtue in below-replacement fertility, India may continue to push its family planning programmes aimed at reducing population size, especially in densely populated regions of the north. Thus one seems justified in assuming a long-term below-replacement fertility scenario for India.

PROJECTION OF TOTAL FERTILITY RATE

While making projections for India, it is useful to keep in mind the following: (i) the base period fertility should be adjusted for under enumeration of births in the SRS; (ii) instead of linear or log-linear projections, TFRs should be projected assuming a S-shaped curve such as the Gompertz; and (iii) because of the vast regional heterogeneity, the all-India TFRs should be derived as weighted averages of state-specific assumptions. Table 5 presents an illustrative projection of TFRs for India and major states up to the year 2051.

First, corrected TFRs for 1997 are derived as follows: The SRS-based TFRs for 1984-90 are corrected by using the average of the under enumeration of births implied by the NFHS analysis for 1978-92 and my own analysis for 1981-91. By assuming the trend in TFR implied by the census-based TFRs for 1984-90 and 1994-90 (see table 1) as correct, the adjusted SRS TFRs for 1984-90 is brought forward to 1994-90, i.e., for circa 1997. In the case of all-India, the corrected TFR is 3.4 instead of the SRS estimate of 3.2.

With the corrected TFRs for 1997, and the estimated values of the parameter *b* for 1982-98 (see table 2), TFRs are projected by single-year time interval using the Gompertz model:[1]

$$TFR_t = \alpha + s\, a^{b^t} \text{, with } t = 0 \text{ at 1997, and,}$$

$$a = \frac{TFR_0 - \alpha}{s} \text{, where } TFR_0 \text{ is the adjusted TFR for 1997.}$$

For all states, the lower limit for TFR (α) has been assumed to be 1.7, as estimated earlier using the differential form of the curve, and s was varied around 5.3, as reported in table 2.

Table 5 shows two estimates for All-India: one that uses the estimate *b* made for 1982-98 (India, unweighted), and the other derived from the weighted averages of the state specific estimates of TFR (India, α = 1.7). According to the first, India will reach replacement fertility by 2011-16. But that based on the weighted average shows that it would be a delayed by at least 5 years because of spatial heterogeneity. Figure 3 compares the trajectory of TFR as proposed here (with α = 1.7) for all India with that assumed under United Nations projections (United Nations, 2001) and by Dyson (2002). While the estimates of TFR proposed now are higher than either that of United Nations or Dyson's up to 2015, they are lower for the sub sequent periods.

Some important state-specific results may also be note. If the current pace of decline were to continue, by 2005, Andhra Pradesh and Himachal Pradesh would join Kerala and Tamil Nadu in attaining the replacement level TFR. Six more states – Karnataka, West Bengal, Orissa, Punjab, Gujarat and Maharashtra would join this group by 2010. Four more states, Haryana, Assam, Madhya Pradesh and Rajasthan are expected join them by 2020. But the two most populous states of Uttar Pradesh and Bihar are not expected to attain replacement fertility until about 2030. Thus, for India to attain replacement fertility by 2016-20, it is imperative for some leading states to have fertility below this level. But for this to happen, how crucial for the TFR to fall up to 1.7 in every state? Table 5 also shows all-India estimates of TFR (state-weighted) derived by assuming the lower limit to be 1.8 instead of 1.7. As can be seen, at the all-India level this makes hardly a difference until 2020. Both sets suggest that TFR would reach replacement level during 2016-20. Thus a marginal difference in the lower limit has no significant bearing on our result that fertility would reach replacement level in India by 2016-20.

[1] For Bihar, the estimated value of *b* for Uttar Pradesh (1.049) was assumed to be applicable instead of its own value (1.074) as the latter was suspected to have been affected by data errors.

Appendix

1. Gompertz Model

Under this model, total fertility rate (TFR) is first rescaled to vary between 0 and 1 by applying the following transformation:

$$y = \frac{TFR - \alpha}{\sigma} \quad , \qquad 0<y<1. \tag{1}$$

where α is the lower limit for TFR , and σ is the difference between the lower and upper asymptotes of TFR.

The transformed variable y is assumed to fall with time (t) according to the Gompertz curve:

$$y = a^{b^t}, \qquad 0<a<1 \text{ and } \; b>1. \tag{2}$$

where the parameter a is the value of y when time $t = 0$ (thus reflects the lag in fertility decline), and b is the parameter that measures the speed of fall.

By differentiating eq (2) with respect to time we have

$$\frac{\partial y}{\partial t} = \frac{1}{\sigma}\frac{\partial TFR}{\partial t} = \ln b \; y \ln y \tag{3}$$

From eqs (1) and (3) we have,

$$\frac{\partial TFR}{\partial t} = \ln b(TFR - \alpha) \; \ln\left(\frac{TFR - \alpha}{\sigma}\right)$$
$$= -\ln b \; \ln\sigma \; (TFR - \alpha) + \ln b(TFR - \alpha)\ln(TFR - \alpha) \tag{4}$$

From eq (4), the model parameters b, σ and α can be estimated by linear regression, using an iterative search procedure for α: Assume a value for α and regressing the changes in TFR on TFR-α and product of TFR-α and logarithm of TFR-α. The regression is carried out without the intercept term, and its residual sum of squares (RSS) is computed. The trail value of α is increased or decreased until RSS of the regression is minimum (or R^2 is maximum). If C_1 and C_2 are, respectively, the estimated coefficients of the first term and the product term in eq (4), then

$$b = \exp(C_2)\,; \qquad \sigma = \exp\left(\frac{-C_1}{C_2}\right).$$

An attempt was made to fit the Gompertz model in this form by using the estimates of state-level TFRs derived from the NFHS and Census data for the 1980s and the 1990s (see table 1). The regression was run by pooling the data from the two sources on the average annual change in TFR for 16 major states. However, information for Assam from the NFHS was not considered as the suggested decline in fertility seemed implausible. The regression gave the following fit:

ΔTFR = -0.0892 (TFR-1.7) + 0.5344 (TFR-1.7) ln (TFR-1.7) R^2 = 0.371; N = 31;

(19.3) (11.65) RSS = 0.0114.

where the figures in parentheses are the t-ratios of the respective regression coefficients. The estimated coefficients suggest the value of b as 1.055 and s as 5.31. The estimate of a was obtained by trail and error: When it was assumed as 1.8, R^2 of the regression was 0.352 and when it was assumed as 1.6, the R^2 was 0.367. Thus, as per the fitted Gompertz model, TFR has a lower limit of 1.7 and an upper limit of 7 (= 1.7 + 5.3). It may also be noted that the fitted curve has a point of inflection at 3.7 (= 1.7+ 0.37×5.3).

When the annual estimates of TFR are available, such as from the Sample Registration System as in India, the model can be fitted using the double-log version of the model in eq (2):

$$\ln\left(-\ln\left(\frac{TFR-a}{s}\right)\right)=\ln(-\ln a)+\ln bt \qquad (5)$$

In fitting the model using eq (5), it would be necessary to assume a value each for a and s. In the state-level analysis using the SRS data reported here, for ever state, a has been assumed as 1.7 as estimated from the census and NFHS data for the 1990s using differential form of the model. But the value of s was varied slightly around the estimated value of 5.3 as there is some evidence to suggest that pre-transitional level of fertility may have somewhat higher in north India than in south India (see Bhat 2000; Guilmoto and Rajan 2001). Also, since there is evidence to suggest that SRS completeness may have changed overtime (Bhat 2002a), two time dummies were included in the model so as to minimize the effect of change in completeness on parameter estimates

$$\ln\left(-\ln\left(\frac{TFR-a}{s}\right)\right)=\ln(-\ln a)+\ln bt+c_1D_1+c_2D_2 \qquad (6)$$

where D_1 and D_2 are set to 1 for the time period 1971-81 and 1982-93, respectively. Thus the coefficients c1 and c2 respectively measure the completeness of births is 1971-81 and 1982-93, relative to the level after 1993. These time periods are chosen keeping in mind the replacement of SRS sampling units affected in 1982 and 1994. If completeness of birth recording had improved in the SRS, the coefficients, c_1 and c_2 would be significantly lower than zero, and $c_2 > c_1$. The average level of birth completeness for any given period, relative to that in the reference period (here, 1994-98) can be obtained by comparing the predicted TFRs from eq (6) with and without the relevant dummy variable term. The results of fitting the model using the annual estimates of TFR from the SRS are discussed in the main text.

2. Logit Model

In the logit model we assume that

$$y=\frac{TFR-a}{s}=\frac{ae^{bt}}{1+ae^{bt}}, \quad b< 0 \qquad (7)$$

where the lag parameter a is the value of $y/(1-y)$ at time $t = 0$, and b represents the speed of decline in fertility.

By differentiating eq (7) with respect to time (t) we have

$$\frac{\partial y}{\partial t} = \frac{1}{s}\frac{\partial TFR}{\partial t} = b\, y(1 - y) \qquad (8)$$

From eq (1) and (8) we have

$$\frac{\partial TFR}{\partial t} = b(TFR - a) - \frac{b}{s}(TFR - a)^2$$

$$= -\frac{b}{s}TFR^2 + \frac{b}{s}(s + 2a)TFR - \frac{b}{s}(sa + a^2) \qquad (9)$$

As eq (9) suggests, the model parameters b, s and a can be estimated by regressing the changes in TFR in a given period on TFR and TFR^2. If C_0 is the intercept, and C_1 and C_2 are, respectively, the estimated coefficients of TFR and TFR^2, then from eq (9) we have

$$b = -\sqrt{C_1^2 - 4C_o C_2}\ ; \qquad a = \frac{-C_1 + b}{2C_2}\ ; \qquad s = \frac{-b}{C_2}\ .$$

The model was fitted to the same data to which earlier we applied the Gompertz model. The result was the following:

$\Delta TFR = 0.1169 - 0.1162\ TFR + 0.0152\ TFR^2$ $\qquad R^2 = 0.340$; RSS = 0.0120; N = 31.
(3.80) (3.79)

The estimated regression coefficients imply a as 1.19, s as 5.28 and b as –0.080. The estimated point of inflection is 3.8 (= 1.2 + 0.5 $\times$ 5.3). Thus the lower limit to TFR suggested by the logit model (1.2) is significantly lower than the one indicated by the Gompterz model (1.7).

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TABLE 1. ESTIMATES OF TOTAL FERTILITY RATE DERIVED FROM REVERSE-SURVIVING THE POPULATION AGE 0-6 YEARS ENUMERATED IN 1981, 1991 AND 2001 CENSUSES, AND ESTIMATES FROM THE SAMPLE REGISTRATION SYSTEM FOR THE CORRESPONDING PERIOD FOR ALL-INDIA AND MAJOR STATES

	Sample Registration System			*Census reverse-survival estimate*			*%t fall, c.1977-87*		*% fall, c.1987-97*		*Change in rate of fall*	
States	*1974-80*	*1984-90*	*1996-98*	*1974-80*	*1984-90*	*1994-00*	*SRS*	*Census*	*SRS*	*Census*	*SRS*	*Census*
Andhra Pradesh	4.27	3.52	2.49	4.30	3.44	2.24	17.5	20.2	29.3	34.7	11.9	14.5
Assam	4.20	3.85	3.22	na	4.11	3.14	8.4	na	16.4	23.6	8.0	na
Bihar	na	5.31	4.38	5.73	5.38	4.59	na	6.1	17.5	14.6	na	8.5
Gujarat	4.92	3.66	3.00	4.61	3.40	2.74	25.6	26.2	18.1	19.6	-7.5	-6.6
Haryana	5.32	4.37	3.41	5.23	4.14	3.17	17.8	20.8	21.9	23.5	4.0	2.7
Himachal Pradesh	4.10	3.52	2.39	4.21	3.26	2.08	14.1	22.6	32.1	36.3	17.9	13.6
Karnataka	3.67	3.47	2.48	4.22	3.36	2.25	5.5	20.3	28.4	33.0	23.0	12.7
Kerala	3.14	2.17	1.83	2.95	2.05	1.75	30.8	30.5	15.8	14.7	-15.0	-15.8
Madhya Pradesh	5.51	4.89	3.98	5.64	4.91	3.80	11.2	13.0	18.8	22.6	7.5	9.6
Maharashtra	3.72	3.50	2.74	4.03	3.45	2.60	6.0	14.3	21.6	24.6	15.5	10.3
Orissa	4.37	3.85	3.03	4.48	3.74	2.77	11.9	16.5	21.4	26.1	9.4	9.6
Punjab	4.36	3.43	2.68	4.33	3.25	2.36	21.3	24.9	21.9	27.4	0.6	2.5
Rajasthan	5.21	4.97	4.17	5.90	5.10	4.21	4.6	13.6	16.0	17.5	11.4	4.0
Tamil Nadu	3.67	2.68	2.01	3.52	2.45	1.78	27.0	30.5	25.1	27.4	-1.9	-3.1
Uttar Pradesh	6.08	5.44	4.73	6.28	5.56	4.51	10.5	11.4	13.0	18.9	2.5	7.5
West Bengal	na	3.60	2.54	4.04	3.58	2.54	na	11.6	29.6	28.8	na	17.3
All India	4.62	4.10	3.32	4.77	4.05	3.17	11.2	15.1	18.9	21.8	7.6	6.7

na – not available.

Figure 1. The relationship between change in TFR to the level of TFR as indicated by state-level estimates from the NFHS (for 1978-92 and 1984-98) and the Censuses (for 1984-90 and 1994-00)

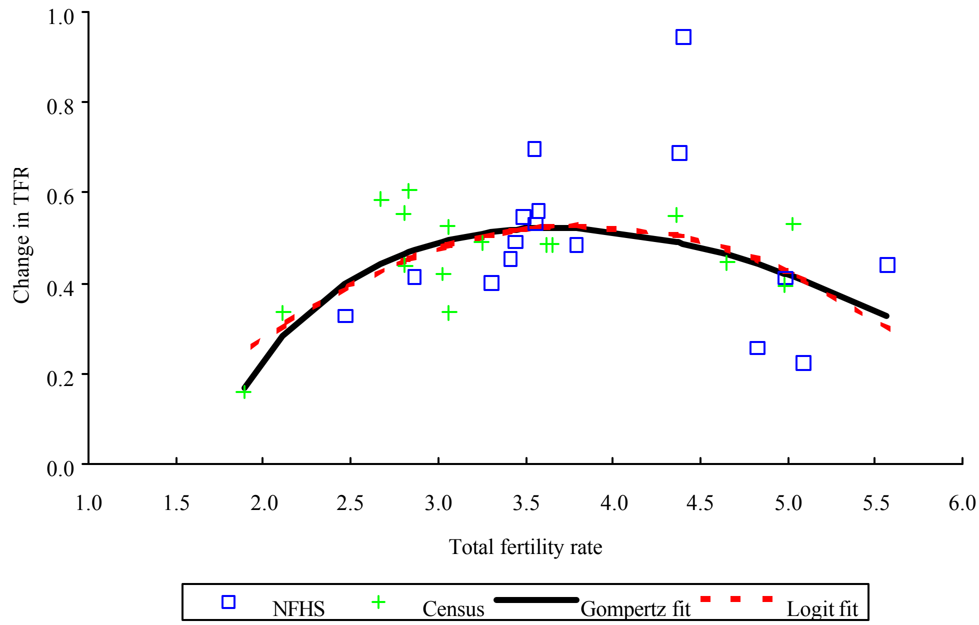


TABLE 2. RESULTS OF FITTING THE GOMPERTZ CURVE TO THE TIME TREND IN TFR FROM THE SRS, FOR INDIA AND MAJOR INDIAN STATES

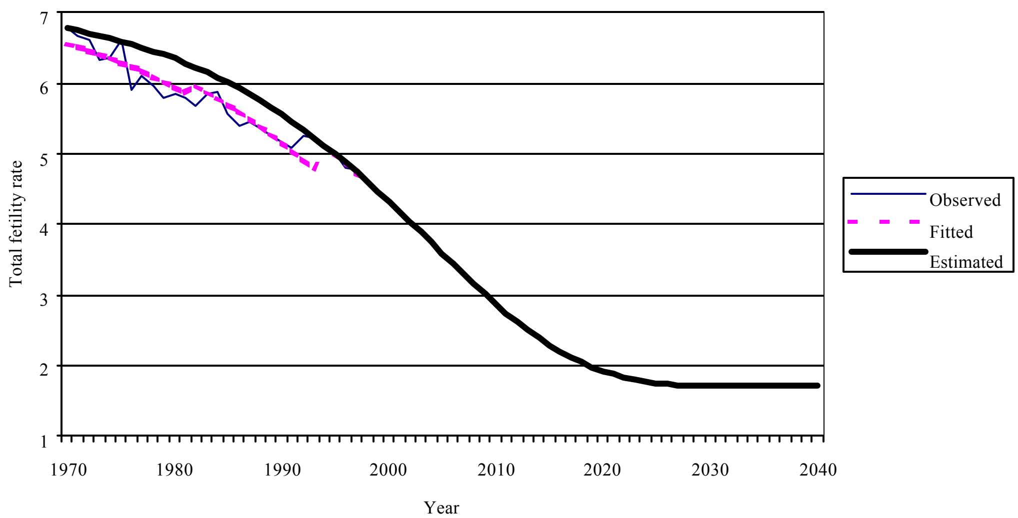
Region, State and assumed value of R	*Period*	*Estimates of model parameters @*		*Relative completeness of recorded TFR @@*		*Model*	*Estimated year when TFR was 90% of maximum*
		a	*b*	*1971-81*	*1982-93*	R^2	
South (R = 5.0)							
Andhra Pradesh	1971-98	0.883	1.061	0.937	0.995	0.959	1953
	1982-98	0.922	1.071	na	0.956	0.961	1959
Karnataka	1971-98	0.773	1.043	0.932	1.050	0.944	1937
	1982-98	0.789	1.045	na	1.041	0.961	1940
Kerala	1971-98	0.932	1.095	0.797	0.833 *	0.910	1959
	1982-98	0.960	1.108	na	0.789 *	0.738	1963
Tamil Nadu	1971-98	0.803	1.057	0.981	0.991	0.955	1943
	1982-98	0.910	1.077	na	0.904 *	0.957	1957
West (R = 5.3)							
Gujarat	1971-98	0.917	1.063	0.956	0.898 **	0.967	1959
	1982-98	0.875	1.053	na	0.933 *	0.941	1952
Maharashtra	1971-98	0.825	1.048	0.854 **	0.962	0.921	1944
	1982-98	0.812	1.046	na	0.970	0.965	1942
East (R = 5.3)							
Assam	1971-98	0.945	1.069	0.805 ***	0.855 **	0.841	1965
	1982-98	0.902	1.055	na	0.895 ***	0.905	1957
Orissa	1971-98	0.890	1.055	0.881 **	0.943	0.931	1955
	1982-98	0.930	1.066	na	0.907 **	0.947	1961
West Bengal	1982-98	0.875	1.058	na	0.999	0.965	1952
North (R= 5.5)							
Bihar	1982-98	0.972	1.074	na	0.950	0.867	1974
Haryana	1971-98	0.993	1.118	0.880 *	0.827 *	0.854	1978
	1982-98	0.930	1.062	na	0.953 *	0.954	1962
Himachal Pradesh	1971-98	0.904	1.067	0.866 *	0.972	0.933	1956
	1982-98	0.880	1.061	na	0.996	0.962	1953
Madhya Pradesh	1971-98	0.919	1.053	0.968	0.990	0.925	1961
	1982-98	0.929	1.055	na	0.982	0.953	1963
Punjab	1971-98	0.908	1.065	0.893 *	0.905 *	0.956	1957
	1982-98	0.805	1.046	na	0.982	0.970	1941
Rajasthan	1972-98	0.966	1.071	0.872 *	0.944	0.725	1972
	1982-98	0.976	1.079	na	0.927 *	0.833	1974
Uttar Pradesh	1971-98	0.980	1.077	0.952	0.941 *	0.893	1977
	1982-98	0.938	1.049	na	0.989	0.889	1967
India (R = 5.3)							
Total	1971-98	0.889	1.052	0.912 ***	0.956 **	0.980	1955
	1982-98	0.899	1.054	na	0.949 ***	0.988	1956
Rural	1971-98	0.917	1.055	0.914 ***	0.955 **	0.979	1960
	1982-98	0.929	1.059	na	0.945 ***	0.988	1962
Urban	1971-98	0.803	1.049	0.856 ***	0.948	0.957	1942
	1982-98	0.817	1.051	na	0.940 *	0.968	1944

* $p < 0.05$; ** $p < 0.01$ and *** $p < 0.001$.

@ In all cases, the regression coeficients from which *a* and *b* are derived are significant at 0.001 level.

@@ Completeness level relative to its level during 1994-98, except for urban India where it is relative to the level during 1993-98; the significance levels shown refer to the coefficients of the dummy variables representing these periods.

Figure 2. The observed, fitted and estimated values of total fertility rates for Uttar Pradesh obtained by fitting the Gompertz curve with time dummies for 1971-81 and 1982-93



NOTE: For 1971-98, the estimated line shows the expected values under the model if birth completeness in the SRS had remained the same as during 1994-98, whereas the fitted line shows the expected values that incorporates variation in birth completeness, thus are closer to the observed values.

TABLE 3. DECOMPOSITION OF CHANGE IN TOTAL FERTILITY RATE BETWEEN 1981 AND 1991 BY EDUCATIONAL LEVEL OF WOMEN, INDIA

Educational level of women	*1981 Census**		*1991 Census**		*Within class decline in TFR*	
	TFR	*Percent women*	*TFR*	*Percent women*	*Amount*	*Percentage of total*
Illiterate	4.8	75.1	4.3	67.3	0.5	48.9
Below Middle	4.3	14.4	3.3	15.5	0.9	20.0
Middle school	3.6	5.0	2.8	7.8	0.8	7.4
Matriculate	2.6	4.3	2.2	7.1	0.4	3.5
Graduate and above	1.8	1.1	1.7	2.4	0.1	0.2
All women	4.7	100.0	3.9	100.0	0.8	80.0
Contribution of fertility change among illiterate						49%
Contribution of fertility change among educated		20.0+7.4+3.5+0.2 =				31%
Contribution of change in educational composition of women =		100.0-80.0 =				20%

* TFRs refer to the one-year period preceding the census.

TABLE 4. CONTRACEPTIVE USE BY EDUCATIONAL LEVEL OF WOMEN, EDUCATIONAL COMPOSITION OF WOMEN AND DECOMPOSITION OF THE INCREASE IN CONTRACEPTIVE PRACTICE RECORDED BY THREE NATIONAL SURVEYS, INDIA 1970 TO 1999

Educational level of women	*Percent using contraception*			*Percent of women in the class*			*Percent contribution of within class increase*	
	ORG survey 1970*	*NFHS-1 1992-93*	*NFHS-2 1998-99*	*ORG survey* 1970*	*NFHS-1 1992-93*	*NFHS-2 1998-99*	*1970-93*	*1993-99*
Illiterate	10.0	33.9	42.9	79.3	62.6	57.4	62.9	71.0
Below Middle	20.7	50.4	55.5	10.9	18.3	19.4	16.1	12.6
Middle school	33.5	50.8	52.2	9.0	7.4	8.5	5.2	1.5
Matriculate and above	56.2	54.7	57.0	0.8	11.7	14.7	-0.3	4.0
All women	13.6	40.6	48.2	100.0	100.0	100.0	83.9	89.0
							1970-93	1993-99
Contribution of fertility change among illiterate women =							63%	71%
Contribution of fertility change among educated women =							21%	18%
Contribution of change in educational composition of women =							16%	11%

Source: Operations Research Group (1971); International Institute for Population Sciences (1995); International Institute for Population Sciences & ORC Macro (2000).

* As this survey used slightly different educational categories, the comparisons shown with the NFHS are only approximate.

Figure 3. Comparison of TFR trajectories as assumed in the projections made by the United Nations and Tim Dyson with that proposed here

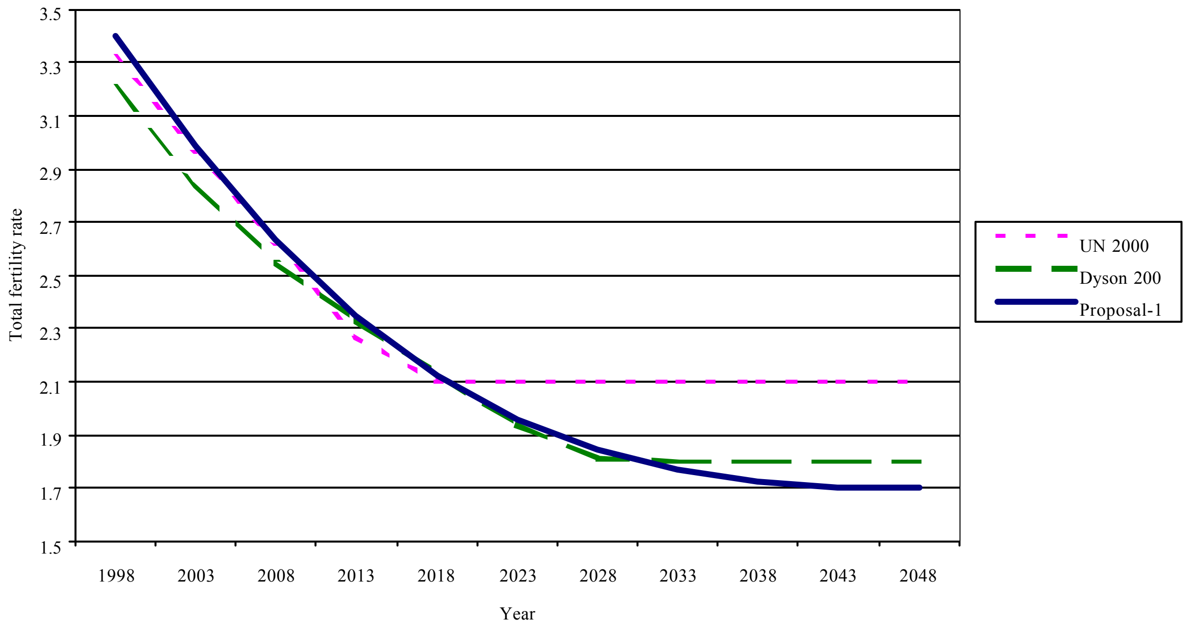


TABLE 5. PROJECTED VALUES OF TOTAL FERTILITY RATE USING THE GOMPERTZ CURVE, INDIA AND MAJOR STATES

States	*Adjusted TFR, 1997*	*Parameter B*	*Projected TFR 1996-00*	*2001-05*	*2006-10*	*2011-15*	*2016-20*	*2021-25*	*2026-30*	*2031-35*	*2036-40*	*2041-45*	*2046-50*
Andhra Pradesh	2.39	1.071	2.30	1.94	1.76	1.71	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Assam	3.66	1.055	3.56	3.05	2.58	2.20	1.93	1.78	1.72	1.70	1.70	1.70	1.70
Bihar	4.89	1.049*	4.81	4.40	3.95	3.49	3.03	2.62	2.26	2.00	1.83	1.75	1.71
Gujarat	3.00	1.053	2.91	2.48	2.13	1.90	1.77	1.72	1.70	1.70	1.70	1.70	1.70
Haryana	3.63	1.062	3.51	2.94	2.44	2.06	1.83	1.73	1.70	1.70	1.70	1.70	1.70
Himachal Pradesh	2.26	1.061	2.19	1.91	1.76	1.71	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Karnataka	2.63	1.045	2.56	2.24	2.00	1.85	1.76	1.72	1.70	1.70	1.70	1.70	1.70
Kerala	1.93	1.108	1.87	1.71	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Madhya Pradesh	3.96	1.055	3.85	3.33	2.84	2.40	2.07	1.86	1.75	1.71	1.70	1.70	1.70
Maharashtra	2.92	1.046	2.84	2.47	2.17	1.95	1.81	1.74	1.71	1.70	1.70	1.70	1.70
Orissa	3.02	1.066	2.91	2.38	2.01	1.80	1.72	1.70	1.70	1.70	1.70	1.70	1.70
Punjab	2.73	1.046	2.66	2.32	2.05	1.87	1.77	1.72	1.70	1.70	1.70	1.70	1.70
Rajasthan	4.41	1.079	4.27	3.54	2.83	2.24	1.88	1.73	1.70	1.70	1.70	1.70	1.70
Tamil Nadu	2.03	1.077	1.97	1.76	1.71	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Uttar Pradesh	4.83	1.049	4.75	4.33	3.88	3.42	2.96	2.55	2.22	1.97	1.81	1.74	1.71
West Bengal	2.78	1.058	2.68	2.26	1.96	1.79	1.72	1.70	1.70	1.70	1.70	1.70	1.70
India, unweighted	3.49	1.054	3.39	2.89	2.46	2.11	1.88	1.76	1.71	1.70	1.70	1.70	1.70
India, state-weighted	3.51		3.42	3.01	2.65	2.36	2.14	1.97	1.86	1.78	1.73	1.71	1.70
Implied per cent change			2.50	12.09	11.81	10.98	9.54	7.70	5.84	4.14	2.60	1.34	0.52
India, with α=1.7	3.49		3.40	2.99	2.64	2.35	2.12	1.96	1.84	1.77	1.72	1.70	1.69
India, with α=1.8	3.49		3.40	2.99	2.65	2.37	2.16	2.01	1.91	1.84	1.79	1.79	1.79

* Assumed to be the same as that of Uttar Pradesh.