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Testing the Suitability of Bongaart's Model in the Context of Fertility Performance in Rural Area of Eastern Uttar Pradesh

Introduction

THE actual level of fertility of any population is always well below its biological maximum or potential fertility and this was pointed out first by Henry (1961). The large gap between the potential fertility and the actual level of fertility is attributed to the effects of a number of biological, behavioural and socio-economic factors. The mechanism through which socio-economic and cultural factors and human behaviour interact with the biological aspects of human reproduction was first identified by Davis and Blake (1956). The term 'Intermediate Variables' was introduced by them for biological and behavioural factors and it was demonstrated that socio-economic and cultural factors affect the fertility through the biological and behavioural factors only.

Following the work of Davis and Blake and incorporating lactational infecundability, Bongaarts (1978) and Bongaarts and Potter (1983) have modified Davis and Blake's list of intermediate variables and proposed a list of eight variables as 'Proximate Determinants of Fertility' and these eight variables are induced abortion, lactational infecundability, marriage, contraception, frequency of intercourse or fecundability, spontaneous intrauterine mortality, duration of fertile period and sterility.

In the present analysis, Bongaart's proximate determinants model is applied to quantify the fertility inhibiting effects of the four important proximate determinants—induced abortion, lactational infecundability, marriage and contraception on fertility. It also examines how well the four principal proximate determinants predict the fertility level and this has been done by comparing the observed total fertility rate with the model-estimated total fertility rate. In

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order to study the trends in the fertility inhibiting effects of the principal proximate determinants and the changes in the fertility levels, we have applied the model to the data obtained at two different points of time during the last decade i.e. during the period 1978 to 1987. The main aims of the present paper are as follows:

(i) To quantify the fertility inhibiting effects of the four principal proximate determinants and to observe their trends during the last decade,

(ii) To identify the proximate determinants which are mainly responsible in influencing the fertility behaviour,

(iii) To decompose the change in fertility into its components during the last decade to assess their specific contributions.

(iv) To project the fertility trends associated with changes in contraceptive practice.

(v) To assess the contraceptive prevalence levels required to reach a fertility target and

(vi) To offer some possible explanations in the case of large discrepancy between observed and the model estimated fertility.

The Data

The data have been taken from two surveys conducted under the auspices of Centre of Population Studies, Department of Statistics, Banaras Hindu University, Varanasi, entitled 'Rural Development and Population Growth : A Sample Survey' and 'Effects of Socio-Cultural Factors on Determinants of Fertility in Eastern Uttar Pradesh (Rural)' in the years 1978 and 1987 respectively. The survey conducted in the year 1987 includes information on age, sex, birth, age of female at marriage, total number of children ever born and surviving including details about duration variable, that is, post-partum amenorrhoea, separation, abstinence, etc. for the births recorded within last 7 years preceding the reference date of the survey.

A couple was defined eligible if both the partners were alive and age of the female was less than 50 years. The survey conducted in the year 1978, includes information on all laws discussed above, except on duration of lactational infecundability.

These records have been utilized to obtain the data for the four indices namely index of marriage, contraception, lactational infecundability and induced abortion because these form the inputs for the application of Bongaart's model.

Reproductive activity outside marriage, is generally rare in rural parts of India. Induced abortion is also not acceptable in rural areas of India except in a few cases such as pregnancy from rape, threat to mother's life, etc. How far abortions influence fertility is difficult to assess because in many cases the people are not willing to part with information due to social stigma and in many cases, it is difficult to distinguish between voluntary abortion and miscarriage. Due to these problems, it was not easy to collect reliable information on abortions in these two surveys. Hence, this factor was not considered in our analysis. The average duration of lactational infecundability is considered to be constant during the period 1978 and 1987 because the survey conducted in 1978 does not provide information on the above factor. As we do not have data on the proportions of current users of different contraceptive methods except the proportion of tubectomy and vasectomy for the survey - 1987, we also assumed that the proportions of different contraceptive methods (other than the proportions of tubectomy and vasectomy), are constant during the above mentioned period. The use-effectiveness of methods used here is from a study conducted in Philippines by Laing (1978).

Theoretical Framework — The Model

The detailed exposition of the proximate determinants model is given in Bongaarts (1978) and Bongaarts and Potter (1983). So, here only an outline of the basic concepts of the model and the variables are discussed.

The fertility inhibiting effects of the four principal variables are measured in the model with the help of four indices and these are :

C_i = Index of lactational infecundability,
C_a = Index of induced abortion,
C_c = Index of contraception, and
C_m = Index of marriage.

These indices can only take values between 0 and 1, when there is no fertility inhibiting effect of a given intermediate variable the corresponding index equals 1; if the fertility inhibition is complete, the index equals 0. The basic structure of the model involves the interrelations among four cumulative fertility rates : the total fertility rate (TFR), the total natural fertility rate (TN), the total marital fertility rate (TM) and the total fecundity rate (TF). The basic relations between the indices and the cumulative fertility measures are :

$$C_m = \frac{TFR}{TM}$$

$$C_c \times C_a = \frac{TM}{TN}$$

$$C_i = \frac{TN}{TF}$$

From these relations TFR can be calculated as :

$$TFR = C_m \times C_c \times C_a \times C_i \times TF \qquad (4)$$

Results and Discussions

Levels and Trends of Fertility Inhibiting Effects of the Proximate Determinants

Table 1 shows the levels of current use of contraceptive methods (in percent), U_{l9} for two point of times i.e. 1978 and 1987. From the table, it is clear that about 21 per cent of currently married women were practicing any method of family planning in 1978 of which 6.7 per cent were for modern methods and 14.5 per cent for traditional methods (including the case of not available also). About 31 per cent of the total use of modem methods is due to the use of modem permanent methods. Among the individual modem methods, tubectomy including vasectomy claims the highest prevalence rate (5 per cent) followed by condom (1.4 per cent), oral pills (0.2 per cent) and IUD (0.1 per cent) in 1978. Here, it is also notable that the proportion of sterilised females has increased by 7.3 per cent from 1978 to 1987. The first panel of Table 2 presents the summary measures of the four principal proximate determinants of fertility. As we have mentioned earlier since no reliable information, was available on induced

TABLE 1 : LEVELS OF CURRENT USE OF DIFFERENT CONTRACEPTIVE METHODS (in percentage) *u*, FOR DIFFERENT YEARS AND THEIR USE-EFFECTIVENESS

Methods	*1978*	*1987*	*Use- Effectiveness (ej Laing(1978)*
Condom	1.4	1.4	0.70
Oral Pills	0.2	0.2	0.90
IUD	0.1	0.1	0.95
Vasectomy + Tubectomy	5.0	12.3	1.00
*Others (including not available)	14.5	14.5	0.70
All *U*	21.2	28.5	
Use-effectiveness *e*	0.774	0.832	

*Safe period, withdraw!, abstinence, etc.

abortions from the surveys, the rates were assumed to be zero. The first two rows of Table 2 provide the total marital fertility rates (TM) and total fertility rates (TFR) as observed in the above surveys. The second panel of Table 2 shows the estimated values of the indices. The lower the indices, the greater is its fertility reducing impact. In fact the index C_m represents the proportion by which TFR is smaller than TM as a result of marriage pattem. Similarly, the index C_c gives the proportion by which TM is smaller than TN with the use and effectiveness of contraception and index C, states that how much TN is smaller than TF due to the effect of lactational infecundability. Thus, in 1978, the marriage pattern reduces actual fertility below marital fertility by 16 per cent (C_m = 0.840). Similarly, in 1987, the above pattern reduces actual fertility below marital fertility by 10.2 per cent (C,,, = 0.898). During the period 1978-1987, the index of contraception declined by 9.6 per cent and index of marriage increased by 6.7 per cent. Thus, the decline in total fertility rate is caused by the increasing effect of contraception.

Table 3 exhibits the magnitude of the total inhibiting effect being accounted by each proximate fertility determinant at two points of time. The differences between the total fecundity (TF), 15.3 and the estimated TFR is attributed as the result of the inhibiting effect of each determinant. The total inhibiting effect is prorated by the proportion of the logarithm

TABLE 2 : ESTIMATE OF SELECTED REPRODUCTIVE MEASURES AND DERIVED INDICES OF FOUR PROXIMATE DETERMINANTS

	1978	*1987*
I. Reproductive Measures		
TM	7.05	6.05
TFR (observed)	5.92	5.43
Proportion of Contraceptive Use (w)	0.212	0.287
Contraceptive Use Effectiveness (e)	0.774	0.832
Total Induced Abortion Rate (TA)	0.0	0.0
Duration of Lactational Infecundability	9.78	9.78
II. Model Indices		
C_i	0.707	0.707
C_m	0.840	0.898
C_c	0.823	0.744
C_a	1.00	1.00
Over all inhibiting effect of the combined Indices		
(C_m xC_ixC_c xC_a)	0.489	0.472
TFR (estimated)	7.48	7.23
Percent TF Over Estimated by the Model	20.86	24.90

of each index to the sum of logarithm of all indices (Wang *et al*, 1987). For example, the fertility inhibiting effect of contraception is obtained as: [15.3 - TFR (estimated)] x$\log C_c$ / ($\log C_{OT} \log C_c + \log C, + \log C_a$) . Similarly, the fertility inhibiting effects of the other factors can be obtained. The results indicate that of a total of 7.82 births in 1978 being inhibited, 1 .90 births or 24.3 per cent are due to the effect of marriage variable, 2.13 births or 27.24 per cent are due to contraception and 3.79 births or 48.46 per cent are due to lactational fecundability. Similarly, in 1987, the contribution of the three proximate variables: marriage, contraception and lactational infecundability to inhibited 8.07 births are, 1.16 births or 14.37percent, 3. 18 births or 39.41 per cent and 3. 73 births or 46.22 per cent respectively (Table 3). Here, it is to be mentioned that, although there is a declining trend in the value of C_m reflecting the increase in proportion of non-married and/or increase in age at marriage but the rate of change is slow for the period 1978 and 1987. It can be asserted that the prevailing cultural and social norms in India, will not permit to change the proportion of non-married and age at marriage for females beyond a certain limit. In India, total reproductive performance takes place within the wedlock and reproduction out of wedlock will never be acceptable to this society. On the other hand, the fertility-reducing effect of lactational infecundability

TABLE 3 : MAGNITUDE OF THE TOTAL INHIBITING EFFECTS ACCOUNTED FOR BY EACH PROXIMATE FERTILITY DETERMINANTS

Proximate Determinants (indices).	*Fertility Inhibiting Effects*			
	Births per Woman		*Percent*	
	1978	*1987*	*1978*	*1987*
Marriage C_m	1.90	1.16	24.30	14.37
Contraception C_c	2.13	3.18	27.24	39.41
Induced Abortion C_a *(assumed)*	0.00	0.00	0.00	0.00
Lactational Infecundability C_i	3.79	3.73	48.46	46.22
Total : 15.3 - TFR (estimated)	7.82	8.07	100	100

The total fertility inhibiting effect is projected by the logarithm of each indices, e.g. Effect of Contraception - {[TF-TFR (estd.)] x log C_c}/(log C_m + log C_c + log C_a + log C_i)

remains almost constant or it may have slightly decreased due to increasing effect of modernization. Thus, we may conclude that future reduction in fertility is largely dependent on marriage variable and contraception variable.

Decomposition of the Change in TFR during the Period 1978-87

To quantify the contribution made by each of the proximate determinants of fertility to an observed change in fertility between two point-times, Bongaarts model given by equation (4) may be written into a decomposition equation as follows:

$$\frac{\text{TFR}(87)}{\text{TFR}(78)} = \frac{C_m(87)}{C_m(78)} + \frac{C_i(87)}{C_i(78)} + \frac{C_a(87)}{C_a(78)} + \frac{C_c(87)}{C_c(78)} + \frac{\text{TFR}(87)}{\text{TFR}(78)}$$

or, $$P_f = P_m + P_i + P_a + P_c + P_r + I \qquad (5)$$

where $P_f = \frac{\text{TFR}(87)}{\text{TFR}(78)} - 1$ = proportional change in TFR between 1978 and 1987.

Similarly, P_m, P_c, P_a and P_i may be defined.

$P_r = \frac{\text{TF}(87)}{\text{TF}(78)} - 1$ = Proportional change in TFR due to a change in the remaining variables.

and TF is estimated as : TFR/($C_m \times C_i \times C_c \times C_a$) and I represents an interaction factor which is easily obtained by subtracting the sum of P_m, P_c, P_i, P_a and P_r from P_f.

Equation (5) simply yields a given proportional change in TFR between two point times which equals the sum of the proportional fertility changes due to the different proximate determinants plus an interaction term. This equation may also be reused to decompose the absolute change in TFR, (TFR (87) - TFR (78)) by multiplying both the sides by TFR (78) yielding :

$$[TFR (87) - TFR (78)] = TFR (78) \times [P_m + P_c + P_a + P, + P_r + I] \quad (6)$$

The decomposition of the change in TFR between 1978 and 1987 is shown in (Table 4). It indicates that TFR declined during this period by 8.28%. This decline in TFR can be

TABLE 4 : DECOMPOSITION OF CHANGE IN TFR BETWEEN 1978 AND 1987

Factor responsible for fertility change	*Percent of change in TFR*	*Distribution of percentage of change in TFR*	*Absolute change in TFR*
Proportion of Women Marriage (P_m)	+6.90	+83.33	+0.41
Contraception Practice $(P_c$	-9.6	-115.94	-0.57
Duration of Post-partum Infecundability (P_i)	0.00	0.00	0.00
Other Proximate Determinants (P_r)	-4.97	-60.02	-0.29
I. (Interaction)	-0.61	-7.37	-0.04
Total	-8.28	100.00	-0.49

decomposed mainly, into 9.6 decline due to an increase in contraceptive use. The change in TFR due to a change in the other proximate determinants is found to be 4.97%. It is evident from the Table 4 that contraception played the highest role in the reduction of fertility during the period 1978-87.

Projection of Fertility Rates Associated with Changes in Contraceptive Use at Some Future Date

Bongaarts and Potter (1983) have also described that how Bongaart's model can be utilized to estimate the level of fertility for a given change in contraceptive prevalence rate at some future date under some simplified assumptions. Thus, assuming that the effect of the other proximate determinants on TF remain constant it can easily be shown that:

$$TFR(0 = TFR(O) \times [1 - 1.08 \times u(t) \times e(t) I C_c (0)] \quad (7)$$

where TFR (t) = Total fertility rate at some future date t,
u (t) = contraceptive prevalence rate at time t,
e (t) = contraceptive use-effectiveness at time t,
TFR(O) = total fertility rate at base year, and
C_c.(0) = index of contraception at base year.

In this analysis, 1987 is taken as base year. Table 5 represents the application of equation (7) to project the TFR at a future date for different levels of contraceptive prevalence rate at that time under the assumption that the use-effectiveness will remain same as in 1987, i.e., *e* (t) = 0.83. The result shows that the decline in fertility varies directly with the increase in contraceptive prevalence. If prevalence rises to 0.4, the TFR would be 4.68 whereas a prevalence of 0.50 would be required to reach a TFR of 4.03.

TABLE 5 : PROJECTED TOTAL FERTILITY RATES AT TIME /, ESTIMATED FROM ASSUMED TRENDS IN CONTRACEPTIVE PREVALENCE AND USE-EFFECTIVENESS

Assumed Contraceptive Prevalence at Time t : (u_t)	*Assumed Contraceptive Use-Effectiveness e (t)*	*Projected Total Fertility Rate at Time t : TFR (t)*
0.35	0.83	5.01
0.40	0.83	4.68
0.45	0.83	4.35
0.50	0.83	4.03
0.55	0.83	3.70
0.60	0.83	3.37
0.65	0.83	3.05
0.70	0.83	2.72
0.75	0.83	2.39
0.80	0.83	2.06

Source : Calculated from :

TFR (0) 5.43, C_c (0) : 0.744, e(0) : 0.83 TFR (t) : TFR (0) x [1 - 1.08 x $(u,)$ x (e_t)] / C_c(0)

TFR *(t) :* TFR at some time *t, u(t)* and *e(f)* are contrceptive prevalence rate and their use-effectiveness at time /. TFR (0) : TFR at base year (1987) C_c (0) : Index of contraceptive at base year (1987)

Contraceptive Prevalence Required to Achieve the Projected Fertility Decline

After a little rearrangement of equation (7), Bongaarts (1984) obtained the following equation which may be utilized to estimate the contraceptive prevalence rate required to reach a protected fertility level. The equation is as follows :

$$U(t) = \frac{1}{1.08 \times (e(t))} \cdot \left[\frac{\text{TFR}(t)}{\text{TFR}(0)} \times C_c(0) \right] \quad (8)$$

As it is often the case that government development plans call for a specific reduction in fertility by a future point of time, the question arises how for contraceptive prevalence is to be raised in order to achieve the targeted fertility level. The above simple equation provides an answer to this question.

Taking 1987 as the base year when contraceptive prevalence and use effectiveness are 0.50 and 0.83 respectively, then the TFR is found to be 4.0. If there is no change in effectiveness, prevalence will have to rise 50 percent if a TFR of 4.00 is to be achieved but to reach a TFR of 3.00 prevalence will have to rise 66%. Of course, if contraceptive effectiveness were to improve, targeted fertility could be obtained with lower prevalence rates. In the extreme case, with all contraceptives consisting of sterilization *(e (t)* = 1.0), only

42% of couples would have to be using contraception to cause the fall of TFR to 4.00. It is to be mentioned here that to obtain a TFR of 3.0, it is necessary to raise the contraceptive prevalence level to 66%, if the present effectiveness remains constant (Table 6).

TABLE 6 : CONTRACEPTIVE PREVALENCE REQUIRED TO REACH A FERTILITY TARGET

Targeted Fertility	*Contraceptive Use-Effectiveness (e(t)}*	*Required CPR (Ut) (in percentage)*
4.5	0.83	43
4.5	0.90	39
4.5	1.00	35
4.0	0.83	50
4.0	0.90	46
4.0	1.00	42
3.5	0.83	58
3.5	0.90	54
3.5	1.00	48
3.0	0.83	66
3.0	0.90	61
3.0	1.00	55
2.5	0.83	73
2.5	0.90	68
2.5	1.00	61
2.0	0.83	81
2.0	0.90	75
2.0	1.00	67

Source **: Calculated from :**

$$U(t) = \frac{1}{1.08 \times e(t)} \cdot \left[1 - \frac{\mathrm{TFR}(t)}{\mathrm{TFR}(0)} \times C_c(0) \right]$$

Some Possible Explanations on the Fitting of Bongaart's Model in the Present Case

We see that Bongaarts model estimated TFRs consistently higher than their observed TFR during the period 1978 to 1987. Table 2 reveals the percentage of over estimates of the TFR by the model. The implication of such over estimation is that the three proximate determinants: lactational infecundability, contraception and marriage explain only a limited extent of fertility reduction. Studies in other Asian countries such as in Nepal, Pakistan (North West Frontier Province) and China have also reported the large discrepancy between observed and model estimated fertility rates (Thapa, 1987; Sathar, 1984; Wang *etal.;* 1987). Naturally the question arises: what are the possible explanations for the discrepancy between the theory and the results. It was further demonstrated that there are some other variables which are excluded in the application of the model which might be responsible for the large discrepancy.

The higher estimates of TFR may be partly due to the low estimates of the observed values of the TFR and errors in the values of the indices of proximate determinants and also partly due to the error term associated with the specification of the model itself.

While applying the model, one important proximate determinant, induced abortion has been ignored due to lack of data on induced abortion. But the evidence from hospital and clinic records and other sources suggest that abortion is not rare suggesting that the prevalence of induced abortion may not be negligible and increased medical facilities and modernization may enhance it. The low average value of fecundability may also largely be responsible for the large discrepancies between the observed and model estimated TFRs. It is due to this fact that the value of TF, which we have considered as 15.3, should be lower. Empirical studies largely based on historical populations of Western Europe, had shown that the normal range of TF varies from 13 to 17 births across populations.

Bongaarts has considered an average value of TF as 15.3 which are largely based on the experience of Western populations. A low average value of TF is found in the societies which are characterized by poverty, frequent spousal separation, social customs and sexual taboos, etc. India is such a country which possesses all the characteristics of below average value of TF. It is therefore, likely that in India TF is lower than 15.3. For India, the estimate of TF is found to be 12 by Arora and Kumar (1987).

One of the most prominent factors affecting fecundability may be due to spousal separation resulting from migration of husbands. Spousal separation affect the fecundability by reducing the exposure period.

Bongaarts and Potter (1979) and Menken (1979) have shown theoretically that the effect of spousal separation may be substantial when the separation period lengthens. Hill (1985) has proposed the addition of a new index C_v (index of spousal separation) to Bongaarts original model which he applied to the data from a rural province in Turkey. The results reveals that spousal separation may account for a 13 per cent reduction in natural fertility. In that population he has taken spousal separation as a separate variable, while analysing the proximate determinants of Beijing. It has also been considered by Wang *et al.* (1987).

Unfortunately, because of the lack of data on spousal separation, the actual fertility inhibiting effect of this factor remains speculative.

The low level of fecundability of the Indian women may also be another consequence which may result in longer waiting time to conception than considered by Bongaarts for estimating the index C_f White deriving the index C_i Bongaarts assumed empirically that in the absence of breast feeding the minimum duration of PPA is 1.5 months and waiting time to conception as 7.5 months. In, India, due to reasons mentioned above, the waiting time to conception may be larger than 7.5 months. Potter *et al.* (1965) reported 10.7 months of waiting time to conception in the case of India. In a recent analysis of WFS data from three Asian countries (Malaysia, Indonesia and Philippines), Trusell *et al.* (1985) observed even larger duration of waiting time to conception which is about 13 months. It may be asserted that in this situation the model will under estimate the index C,. The lack of fitting of the model may arise due to the errors of the measurement of the indices due to poor data quality. Also a lower reported use of contraceptive than actual level can also produce fertility over estimated.

In light of the above discussions, we re-estimate the index of lactational infecundability C, and TF value under alternative assumptions with view to improve the fitting of the model. The index *C,* has been re-estimated by assuming that the waiting time to conception is 13.2 months in rural part of Eastern Uttar Pradesh (Singh, 1993). Thus, the birth interval, in absence of breastfeeding becomes 34.0 months assuming for the amenorrhoea period in the absence of breast-feeding, 2 months for pregnancy wastage and 9 months for gestation. Hence the index C, is modified as :

$$C_i = \frac{25.7}{24.2 + i}$$

where *t* is the average duration of lactational infecundability. Also for a waiting time to conception, 13.2 months, an estimate of TF is found to be 11.67 = 300/25.2 births per woman. So it is suggested that the TF value for India, may be taken around 11.67 rather than 15.3 as suggested by Bongaart for the most of the populations. All the re-estimated values are presented in column II in Table 7 with the re-estimated values of the index C, and TF. The new estimates of TFRs for 1978 and 1987 are 6.10 and 5.89 respectively.

TABLE 7 : ESTIMATES OF THE INDICES OF THE PROXIMATE DETERMINANTS AND OF THE FERTILITY LEVELS FOR THE YEAR 1978 AND 1987

Indices	*I*		*II*	
	1978	*1987*	*1978*	*1987*
C_i,	0.707	0.707	0.756	0,756
C_c	0.823	0.744	0.823	0.744
C_m	0.840	0.898	0.840	0.898
C_a	1.00	1.00	1.00	1.00
TF	15.3	15.3	11.67	11.67
TFR (estd.)	7.48	7.23	6.10	5.89
TFR (obsd.)	5.92	5.43	5.92	5.43

Estimate referring to Column I are based on the data in the first panel of Table 2; II with re-estimated values of C*i* and TF.

This improves the fitting of the model to some extent. Although, there are still gaps between observed and estimated TFRs. This may be due to omission of some important factors or measurement error or specification error.

Conclusion

In the present paper, we have tried to increase understanding about the important factors affecting fertility. Bongaarts proximate determinants model is applied to estimate the fertility inhibiting effect of the three important proximate determinants : lactational infecundability, marriage and contraception. This analysis shows that though the fertility level is declining, although it is still very high. This high fertility is characterized by high nuptiality and low age at marriage and low use rate of contraception. Of the three considered proximate determinants, contraception has become important factor which shows highest role to bring down fertility level from 5.92 births per woman in 1978 to 5.43 births per woman in 1987. Thus, we see that the fertility reducing effect of contraception is increasing and we may expect that the use of contraception would be the main dominant factor of reduction in fertility in future. On the basis of the present study, the national goal of attaining replacement level of fertility could also be expected.

The Bongaart's model estimated TFR is higher than the observed TFR showing that the model is not providing a good fit. The large discrepancy between theory and result may be due to ignorance of some additional important proximate determinants.

In order to achieve fertility decline in future, the present study suggests the following population control policy implications as:

(a) Since the average age at marriage for women is negatively associated with the birth rate, therefore, age at marriage of women specially in rural areas should be increased,

(b) Information about the costs and benefits of longer breast feeding should be provided to women which will play an important role in reducing the fertility and

(c) Since contraception is a valuable technological instrument for lowering the birth rate, therefore, women and men should be encouraged for the use of contraception.

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Appendix

Estimation of the Indices

The indices may directly be estimated as follows (as given by Bongaarts):

$$C_m = \frac{\text{TFR}}{\text{TM}} = \frac{\sum m(a)\cdot g(a)}{\sum g(a)} \tag{A.1}$$

where $m(a)$ = age-specific proportion of women currently married,
$g(a)$ = age-specific marital fertility rate and

$$C_c = 1 - 1.08 \times U \times e \tag{A.2}$$

where m = proportion currently using contraception (including male method also) among married women of reproductive age,
e = average use-effectiveness of the contraception and 1.08 is a sterility correction factor.

The average use-effectiveness of contraceptive methods is calculated as the weighted average of the method specific use-effectiveness, e_i, where the weights are the proportion of women using a given method, u_i.

Thus, giving $U = \sum u_i$ and $e = \frac{\sum e_i u_i}{\sum u_i}$

$$C_a = \frac{\text{TFR}}{\text{TFR} + 0.4(1+u)\text{TA}} \tag{A.3}$$

where TA = total abortion rate.

TA describes the average number of induced abortion per woman at the end of the reproductive period if induced abortion rates remain at prevailing levels for women in reproductive age group. An exact measure would be the sum of the current age-specific abortion rates (multiplied by five; if it is given in five-year age-groups). An approximate measure which is suggested by Bongaarts, is to calculate an annual general abortion rate by dividing the number of induced abortion in the population by the number of women aged 15-49 and then to multiply this average rate by 30 which is the number of years of potential exposure.

$$C_i = \frac{20}{18.5 + i} \tag{A.4}$$

where / = average duration of lactational infecundability.

If in a population all women get married at early age and breast-feeding and post-partum abstinence, induced abortion and contraception were not practiced, the total fecundabiliry rate (TF) is the expected number of children which the women will have during their reproductive age-span. In the absence of breast-feeding and post-partum abstinence, the duration of post-partum infecundability is said to be 1.5 to 2 months on the average as suggested by Bongaarts and Potter (1983). If the average natural waiting time to conception is 7.5 months and an additional 2 months for pregnancy wastage, plus 9 months full gestation period, theoretically a woman could bear 15 children on average within her 25 years (300 months) of reproductive life span (300/(1.5 + 7.5 + 2.0 + 9.0)). Bongaarts and Potter (1983) urged that although the TFR, TM and TN vary widely among populations, the total fecundity rate (TF) is rather stable lying between 13 to 17 births per woman with a standard value of TF = 15.3. As no direct estimate of TF value is available, we have also taken it as 15.3 for application purpose of the model. Further discussion on the value of TF is contained in the text in the section on explanations on fitting Bongaart's Model