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A MODIFIED VERSION OF THE POPULATION COUNCIL'S FERTILITY MODEL WITH SPECIAL REFERENCE TO BANGLADESH

BY

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FOREWORD

I am pleased to introduce this research monograph which presents a modified version of the Population Council's fertility model, with special reference to Bangladesh. The subject is obviously of much importance to this country. Nishkem Agerwal is a staff member of USAID/Bangladesh Mission, and he has conducted this study as a personal contribution, in addition to his project assignment, in association with two freelance researchers. The views expressed are the author's own, and not necessarily of the USAID/Bangladesh. However, I want to encourage this type of applied research through which staff members can present new ideas, to initiate discussion on possibilities of finding new solutions to developmental problems of this country.

John R. Westley
Director, USAID/Dhaka

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1. Introduction..... 1

2. A Brief Description of the Population Council's Fertility Model..... 6

3. Unsatisfactory elements of the model from the viewpoint of users in Bangladesh.....12

4. A modified version of the Fertility Model.....21

5. Application to Bangladesh and new results obtained....43

6. Conclusion.....54

Appendix Tables

1. INTRODUCTION

A dynamic relationship between contraceptive prevalence rates and fertility levels is an important field of applied demographic research for population planners in Bangladesh. One of the most useful models that helps in quantifying this relationship is called "The Population Council's Target-Setting Model", a user's manual for which has been published by the Population Council, New York in December 1986. This model and the computer program "TARGET" associated therewith yields, among other things, an estimate of contraceptive prevalence rate that needs to be achieved in a target year to bring about a given reduction in fertility.

There are two versions of the model, namely :-

a) aggregate model, and

b) age-specific version.

The aggregate model estimates the overall rate of contraceptive prevalence needed for achieving a target expressed in terms of the "total fertility rate" (TFR). The age-specific version provides such an estimate for each five-yearly age-group (namely 15-19, 20-24 and so on upto 45-49), the target being expressed in terms of the "age-specific fertility rates" (ASFR). It facilitates computational work if all the age-groups refer to women.

With regard to the comparative accuracy of the estimates provided by the two versions, the Population Council's manual referred to above gives the following assessment:-

"The age-specific model gives an estimate of overall prevalence in the target year that is not necessarily exactly the same as the corresponding prevalence from the aggregate model. The reason for this generally minor discrepancy is that the age-specific model takes into account variations in the age structure of women of reproductive age. Since the aggregate model ignores these variations, the age-specific version provides more accurate estimates". /1

However, the input data needed for the age-specific version raise two important questions:

i) How wide may be the margin of error if an attempt is made to express a fertility target for a future year in terms of age-specific fertility rates which will necessarily involve subjective judgment?

ii) What can we say about the methodological impeccability of a model which assumes that age-specific fertility rates can be predicted with such accuracy as to enable their use as an input? This type of objection is particularly forceful in Bangladesh because of uncertainty about the current ASFR's themselves, not to speak of their predicted values.

In reply to the above questions, one could say that those who are unhappy about the age-specific version should remain content with the aggregate model. There is no doubt that the aggregate model has been found to be very useful to those responsible for the family planning program in Bangladesh. But an exclusive use of the aggregate model (if not supplemented by an age-specific version) suffers from another type of shortcoming, namely that the target is expressed here in terms of the total fertility

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/1 Bongaarts, J. and Stover, J.: The Population Council Target-setting Model - A User's Manual. The Population council, New York, 1986, pp 12-14

rate, and there is no possibility of a simultaneous estimation of the crude birth rate(CBR). The practical difficulty and confusion arising from this situation is well illustrated in the context of target-fixing for 1990-1991. It is now commonly agreed that the family planning program in the country should be rapidly expanded so as to achieve a contraceptive prevalence rate (CPR) of 40% by the end of the Third Five Year Plan. According to the aggregate model, this level of CPR by 1991 corresponds to a TFR target of 4.8. This represents a reduction of nearly 24% in 10 years in comparison to a TFR value of 6.3 in 1981. However, the model does not provide a direct answer to an important, related question, namely, "how much decline in the crude birth rate (CBR) can be achieved at the same time" ?

Indirect answers to this question are currently attempted through a variety of methods and procedures, including the following:-

a) by using a regression equation between CBR and CPR (contraceptive prevalence rate). A commonly used form of the equation was derived by Nortman (1980) on the basis of data for 32 developing countries:

$$CBR = 46.9 - 42.0u \quad \text{where } u = \frac{CPR}{100}, \quad (R^2 = 0.91)$$

A slightly different equation has been suggested by Mauldin and Segal (1986):-

$$CBR = 49.07 - 0.43CPR \quad (R^2 = 0.84).$$

However, if these equations are applied to Bangladesh for 1991 when CPR is planned to be 40%, then the estimated value of CBR at the end of the Third Five Year Plan would be 30.1 by the first

equation and 31.87 by the second equation. It can be shown (as we shall do in this monograph in section 5) that both these are gross under-estimates.

b) by using two separate models, one linking TFR and CPR in a fertility model, and the other linking CBR to variables like crude death rate and life expectation in a population projection model, the underlying assumption being that since the two models have some common elements, the CBR values given by the second model might be consistent with the values of TFR and CPR given by the first model. Again such an assumption need not be valid. The point to be stressed is that, in the absence of a direct relationship between CPR, TFR and CBR, unrealistic CBR targets can be tagged on to realistic TFR targets.

c) by presuming that the same ASFR's which are used as an input in the age-specific version of the Population Council's model will be multiplied by the number of women in the respective age-groups to calculate the number of births, and that will help compute CBR. But such a procedure will necessarily involve subjective judgment for predicting ASFR and will be considered as a methodological weakness, particularly in countries like Bangladesh, as already mentioned above.

In this monograph we consider as realistic the aggregate model of the Population Council, but superimpose upon it a modified version of the age-specific model. An attempt has been made to remove the two main shortcomings of that model, which specifically implies the following:-

- In our model, the age-specific fertility rates are shifted from the package of inputs to the package of outputs. Of

course, the inputs have to be suitably completed in some other way;

Both TFR and CBR are directly linked to the age-specific contraceptive prevalence rates (CPR).

In order to present a self-contained monograph, we give, in the next section, a brief description of the Population Council's model. In section 3, the two main shortcomings of this model are discussed in a technical way.

Theoretical considerations justifying the basic approach and methodology of our model are given in section 4. Section 5 then presents detailed results obtained by applying the model to Bangladesh, with the help of two self-devised computer programs.

Finally, section 6 contains a brief overview of the results obtained, indicating what further action is suggested thereby on the part of demographers and population planners in Bangladesh. On our part, we view this monograph as the first in a series through which we hope to present further results that our model is capable of producing.

2. A BRIEF DESCRIPTION OF THE POPULATION COUNCIL'S FERTILITY MODEL

The Population Council has formulated a multiplicative model, the central equation of which (relating to any given point of time) is:

$$TFR = C_m \times C_c \times C_a \times C_i \times TF \qquad \text{.....(2.1)}$$

where: TFR = total fertility rate

C_m = index of marriage

C_c = index of contraception

C_a = index of induced abortion

C_i = index of postpartum infecundability

TF = total fecundity rate

and all the indices can take values between zero and one.

The mathematical formula for the four indices are the following:-

$$C_m = \frac{\text{Currently married women in an age-group}}{\text{All women in the same age-group}} \qquad \text{....(2.2)}$$

The relevant age-group for the aggregate model is 15-49 whereas the age-specific version considers the age groups 15-19, 20-24, and so on up to 45-49.

$$C_c = 1 - sue \qquad \text{...(2.3)}$$

where s is the sterility correction factor, u is $\frac{CPR}{100}$, that is the contraceptive prevalence rate divided by 100, and e is the average use-effectiveness of contraceptive methods.

The values of the overall and age-specific sterility correction factors, as suggested by the Population Council, are:

Age-group	Value of s
15-29	1.02
20-24	1.02
25-29	1.03
30-34	1.04
35-39	1.12
40-44	1.33
45-49	2.08
Overall for the age-group 15-49	1.08

Bongaarts & Potter (1983) have shown that the overall value (1.08) is obtained if a weighted average is taken of the age-specific values, the weights being the relative values of natural fertility rate as given by Coale and Trussell (1974).

Average values of the use-effectiveness(e) of the different contraceptive methods are:

Method	Value of e
Male sterilization (Vasectomy)	1.00
Female sterilization(Tubactomy)	1.00
Injectables/Norplant	0.98
IUD	0.95
Oral Pill	0.90
Foam/Jellies	0.80
Condom	0.80
Traditional methods	0.70

Given any method-mix, a (weighted) average value of a can be calculated.

$$C_a = \frac{TFR}{TFR + 0.4 \times (1 + C_c R) \times \text{Total induced abortion rate}} \quad \ldots(2.4)$$

where the total induced abortion rate is the average number of induced abortions per woman at the end of the reproductive period. The functional form of C_a is such that it decreases slowly as TFR goes down.

$$C_i = \frac{20}{18.5 + i} \quad \ldots.(2.5)$$

where i is the average duration of postpartum infecundability (in months) caused by breast-feeding or postpartum abstinence. The functional form of C_i is such that it has a slowly increasing trend over time because the average duration of breast-feeding is getting shorter in comparison to the rather traditional value that has so far prevailed in Bangladesh.

Detailed theoretical justification for the above formulas has been given by Bongaarts & Potter (1983).

The total fecundity rate (TF) can be assumed to have a fairly stable value within a narrow range centered at 15.3.

Three of the four indices namely C_m, C_c and C_a take different values for the seven five yearly age-groups (15-19 to 45-49). For example, an increase in the age at marriage means a decreasing value of C_m in the age-group 15-19, but it may not have any effect on the age-group 45-49 (except in the long run).

Similarly, C_c varies from one age-group to another, partly because the sterility correction factors are different and partly because the contraceptive prevalence rates, when plotted against age, usually have the shape of an inverted U-distribution. Furthermore, the contraceptive method-mix generally varies with age, and the average value of e is higher in those age-groups where sterilisation acceptors constitute a relatively higher proportion of contraceptive users.

The third index C_a is difficult to measure in traditional societies where induced abortion is believed to be negligible (which implies C_a to be close to one). Bongaarts and Potter (1983) assumed C_a to be one for Bangladesh for 1975. In that case, the same value (one) would apply to all the age-groups. However, to be realistic, we can assume that some cases of induced abortion do take place, particularly in the younger age-groups, although they often remain unreported or under reported. The formula (2.4) gives overall values of C_a which show a declining trend over time. Age-specific values can thus be assumed so as to be consistent with the overall C_a.

Regarding the fourth index C_i, Bongaarts and Potter have explained why it can be generally assumed to be age-invariant (at any given point of time, because over time it is slowly increasing).

"Although postpartum infecundability in reality rises slightly with age, the other components of birth intervals increase also, so that the fertility-inhibiting impact of postpartum infecundability changes very little with age. It is, therefore, simpler and more convenient to use the same equation for C_i in all age-groups and to assume the duration of postpartum infecundability to be age invariant". /2

The aggregate fertility model is based on an extension (over time) of the central equation (2.1) so as to include the base year (0) and the target year (t), and by considering the following ratio:

$$\frac{TFR(t)}{TFR(0)} = \frac{C_m(t) \times C_c(t) \times C_a(t) \times C_i(t) \times TF(t)}{C_m(0) \times C_c(0) \times C_a(0) \times C_i(0) \times TF(0)} \quad \ldots(2.6)$$

Since our main interest is in C_c, its effect can be isolated by combining the ratios of the other indices into a single factor F(t), which means that

$$F(t) = \frac{C_m(t) \cdot C_a(t) \cdot C_i(t) \cdot TF(t)}{C_m(0) \cdot C_a(o) \cdot C_i(o) \cdot TF(0)} \quad \ldots(2.7)$$

Assuming that all other terms are known except u(t) which is $\frac{CPR}{100}$, then a simple re-arrangement of terms leads to the formula

$$u(t) = \frac{1}{1.08 \times e(t)} \cdot \left[1 - \frac{TFR(t)}{TFR(0)} \times \frac{1}{F(t)} \times [1 - 1.08 \times u(0) \times e(0)]\right] \ldots(2.8)$$

/2 Bongaarts, J. and Potter, R. G., Fertility, Biology, and Behavior, An Analysis of the Proximate Determinants, Academic Press, New York, 1983, pp.116-7

This formula enables us to estimate, with a reasonable degree of accuracy, the contraceptive prevalence rate that needs to be attained in the target year for achieving a given TFR target. To facilitate practical applications, the "TARGET" program of the Population Council assumes that TF[t] = TF[0].

In the age-specific version, similar formulas are applied seperately to each five-yearly age-group except that the total fertility rate and the total abortion rate are replaced by their age-specific equivalents. Without going into detail we write below the age-specific equivalent to formula [2.8], using the letter "a" to refer to each age-group ranging from 15-19 to 45-49:-

$$u[t,a] = \frac{1}{SCF[a]\ e[t,a]}\left[\ 1 - \frac{ASFR[t,a]}{ASFR[0,a]} \times \frac{1}{F[t,a]} \times \right.$$

$$\left.\{\ 1 - SCF[a] \times u\ [0,a] \times e\ [0,a]\ \}\right] \quad ...[2.9]$$

where SCF stands for age-specific sterility correction factor. Values of this factor, ranging from 1.02 [for age 15-19] to 2.08 [for age 45-49] have already been shown above.

3. UNSATISFACTORY ELEMENTS OF THE MODEL FROM THE VIEWPOINT OF USERS IN BANGLADESH

Although the Population Council's fertility model is a useful tool in the hands of demographers in Bangladesh, we feel it to be inadequate in two important respects. The purpose of this section is to draw attention to these inadequacies with a view to indicating the type of modifications that are particularly necessary and which we have tried to introduce in this monograph.

Neglect of CBR-targeting

One of the most obvious deficiencies of the model is that it has given a step-motherly treatment to the subject of crude birth rate (CBR) in comparison to that of total fertility rate (TFR). In making this statement, we are not questioning the pivotal role that rightfully belongs to TFR in fertility analysis. Our criticism is prompted by the following considerations:-

(i) The model provides an estimate of contraceptive prevalence rate (CPR) that will be required to achieve a TFR target. However, corresponding to the same values of TFR and/or CPR, different demographers have made widely differing estimates of CBR. In the absence of a clear linkage, within the model, between TFR and CBR, the users of the model are helpless in preventing such a chaotic situation.

ii) Once an impression is created that CBR values can be selected within a fairly wide range of possible choices, without violating the fertility model, planners are

naturally tempted to fix a low CBR-target. The current state of affairs in Bangladesh can thus be characterised as being subject to two risks, namely (a) unrealistic CBR-targets are tagged on to realistic TFR targets, and (b) any evaluation based primarily on TFR targets can give a false sense of achievement.

A concrete example of the alarming situation referred to in the preceding paragraph can be given from the Third Five Year Plan 1985-90. One of the main tools specified in the plan for achieving a rapid fertility decline is that the contraceptive pre alence rate among eligible couples should be increased to 40% by 1990. This estimate of CPR is practically the same as obtained from the Population Council's fertility model, the target being a reduction of TFR to 4.8 in 1991. The point to be stressed, however, is that the plan document makes no mention of the TFR target; it envisages, instead, a decline in the CBR to as low as 31 by 1990. Anyone using the model in a mechanical and superficial manner might get the impression that a CBR target of 31 may be consistent with a TFR target of 4.8, since both are tied to a CPR of 40%. Under Bangladeshi conditions, such an impression is unjustified, and we shall demonstrate in section 5 that while a CPR of 40%, coupled with a suitable re-allocation of effort and resources, may well be adequate to achieve a TFR target of 4.8, it may fall far short of achieving a CBR target of 31 by 1990. It would obviously be desirable to have an in-built check within the fertility model itself which can discourage planners from fixing unrealistic CBR-targets.

Rather than giving more examples of this type, it is better to raise a theoretical question: Is there a one-to-one correspondence between a TFR-target and a CBR-target, and if not, which is the more difficult target to achieve by raising CPR to a certain level ? An answer to this question is best given through a simple mathematical formulation as shown below:

$$TFR = 5 \sum ASFR \qquad \text{.....(3.1)}$$

which means that TFR is obtained by adding the age-specific fertility rates for the age-groups 15-19, 20-24,..., up to 45-49, and then by multiplying the sum by 5 (because each age-interval is 5 years). Obviously, TFR is a multiple of an unweighted sum of ASFR's. Also, any given value of TFR can be obtained by a combination of many possible values of ASFR's.

CBR involves a weighted sum of ASFR's, the weights being the number of women in the age-groups 15-19, 20-24,..., upto 45-49.

$$CBR = \frac{1000}{P} \sum AWRA \times ASFR \qquad \text{.....(3.2)}$$

where P denotes the total population of the country, and AWRA stands for "all women in the reproductive age-groups". The term AWRA is to be distinguished from MWRA which means "married women in the reproductive age groups". Since AWRA's are different in the various age-groups, they cannot be shifted outside the summation. Like the TFR, any given value of CBR can be obtained through many possible values of ASFR's.

Each of the equations (3.1) and (3.2) is linear in seven ASFR's since there are seven five yearly age-groups within the total age-range of 15 - 49. If we envisage a seven-dimensional

mathematical space, then all values of ASFR's lying on a plane of the type

$$Y_1 + Y_2 + Y_3 + Y_4 + Y_5 + Y_6 + Y_7 = \text{constant}$$

would satisfy a given TFR target. At the same time, all values of ASFR's lying on another plane of the type

$$a_1y_1+a_2y_2+a_3y_3+a_4y_4+a_5y_5+a_6y_6+a_7y_7 = \text{constant}$$

would satisfy a given CBR target.

These two planes are not parallel. However, even the plane of intersection does not uniquely determine all the ASFR's because there are only two equations in seven unknowns. This is a mathematical way of saying that, in general, there is no one-to-one correspondence between a TFR-target and a CBR-target.

The nature of the discrepancy between these two targets can be approximately shown in a two-dimensional geometrical plane if we pool the seven age-groups in two suitable sub-groups. One possible way of pooling, which is suggested by real-life observations, is to consider 15-29 as one broad age-group, and 30-49 as another broad age-group.

Let us then introduce the following notation:

W_1 = All women in the age-group 15-29

W_2 = All women in the age-group 30-49

B_1 = Live births to women in the age-group 15-29

B_2 = Live births to women in the age-group 30-49

Then B_1/W_1 is a pooled estimate of ASFR in the age-group 15-29 which is spread over 15 years. Similarly, B_2/W_2 is a pooled estimate of ASFR in the age-group 30-49, which is spread over 20

years. Obviously, pooling introduces a certain degree of error, but it helps in making a graphical presentation of what had to be visualised in a seven-dimensional space.

Equations (3.1) and (3.2) can now be re-written as

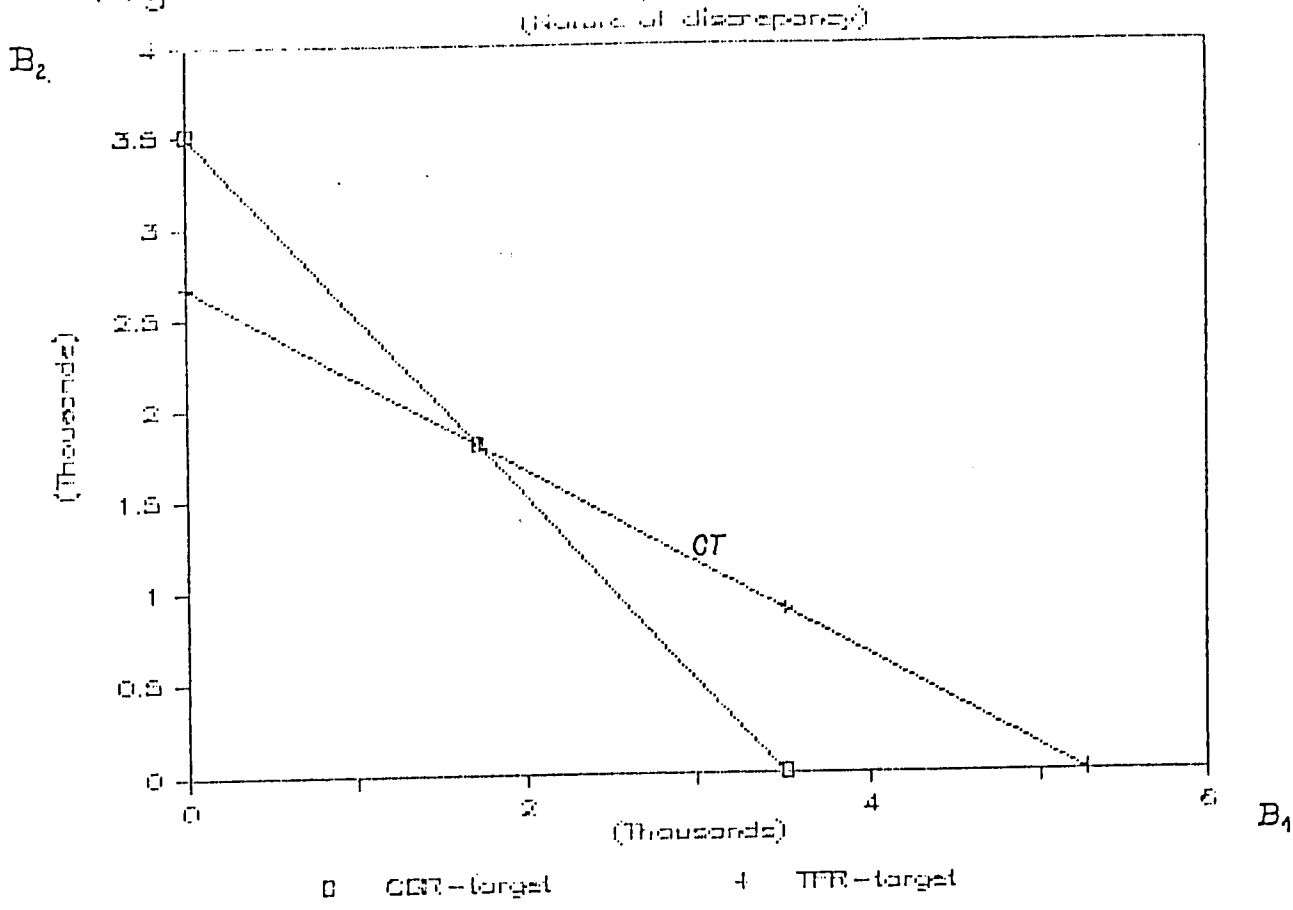
$$TFR = 15 \frac{B_1}{W_1} + 20 \frac{B_2}{W_2} \qquad .....(3.3)$$

$$CBR = \frac{1000}{P} (B_1 + B_2) \qquad .....(3.4)$$

By showing B_1 along the x-axis and B_2 along the Y-axis, equations (3.3) and (3.4) represent two straight lines, for given values of TFR and CBR. (see figure 3.1). For the purpose of this graph, we assume a TFR target of 4.8 and a CBR target of 31 for 1991. Values of W_1, W_2 and P for 1991 are taken from available projections. Small errors in these as well as those arising from the pooling of age-groups do not invalidate the main point of our argument in the present illustration.

Figure 3.1 shows that a CBR-target of 31 can be satisfied only if the total number of live births in 1991 does not exceed 3514. On the other hand, a TFR-target of 4.8 is not so restrictive and it can be satisfied, for example, even if total births in 1991 are as many as 4150, provided only that 2,900 of these births will be to women below 30 years of age. A simultaneous satisfaction of both the CBR and TFR targets will be possible only if total births are 3514 of whom a majority will be to women over 30 years of age. It will be shown in section 5 that the chances of this happening in 1991 are very slim.

Figure 3.1:TFR–target versus CBR–target



In the light of trend-based and other projections, there is a high probability that the point (B_1, B_2) in figure 3.1 may be on the segment marked CT on the TFR-target line (or in an area adjacent to it). More details relating to this will be provided (in section 5) in connection with the modified version of the Population Council's model. The main purpose of referring to this aspect at this stage is to highlight the need for a clear linkage, within the model, between the targetted or estimated values of TFR and CBR, and this must involve also the third important factor, namely CPR.

Use of ASFR as an input

Another deficiency of the Population Council's model is that it considers the age-specific fertility rates of the target year, i.e. ASFR(t) as an input. In other words, we are supposed to know in advance what the seven ASFR's will be in the target year. These and other inputs will then help in estimating, through the model, the required rates of contraceptive prevalence in the various age-groups.

One can appreciate why ASFR(t) has been considered as an input in the model. This is because the age-specific version of the model is viewed as a simple extension of the aggregate model. In the aggregate model, TFR(t) is an input and CPR(t) is an output. By a simple analogy, TFR (t) is replaced by ASFR(t) in the age-specific model. However, this is only one of the ways of moving from an aggregate to an age-specific version. It is

possible, and theoretically preferable, to think of other ways, because an age-specific version offers plenty of scope to introduce methodological sophistication as well as linkage between TFR and CBR (which is not possible in an aggregate model).

Our specific comment is that the simple procedure of considering ASFR(t) as an input should be replaced by a more complicated procedure which is justified by its capability to yield better results. Of course, the revised procedure will have to be viewed as a sequence of steps.

Let us consider the possibility of introducing simultaneous and inter-dependent changes over time in ASFR as well as in age-specific CPR such that the ratio

$$\frac{ASFR(t)}{1 - s.u(t)e(t)} \qquad \ldots\ldots(3.5)$$

takes values which can be predicted, s being the age-specific sterility correction factor, u is the age-specific CPR and e is the age-specific use-effectiveness of the contraceptive methods. In the terminology and notation of the Population Council's model, the ratio (3.5) represents

$$\frac{ASFR(t,a)}{C_c(t,a)}$$, "a" referring to age-group and it can be

assumed to take the value

$$\frac{ASFR\ (0,a)}{C_c(0.a)} \cdot \frac{C_m(t,a)}{C_m(0,a)} \cdot \frac{C_e(t,a)}{C_e(0,a)} \cdot \frac{C_i(t,a)}{C_i(0,a)} \qquad \ldots(3.6)$$

where C_m is the index of marriage, C_a is the index of induced abortion, C_i is the index of postpartum infecundability, and all terms containing (o) refer to the base year whose values can be assumed to be known. That leaves three terms referring to the target year, namely C_m, C_a and C_i. Of these, C_i can be assumed to be age-invariant, but C_m and C_a vary with age. Therefore, another ratio, namely

$$\frac{ASFR(t,a)}{\{1-s(a).u(t,a).e(t,a)\}.C_m(t,a).C_a(t,a)} \qquad ...(3.7)$$

is preferable to ratio (3.5) from the viewpoint of identifying a relatively more stable input that can take the place of ASFR (t). This ratio can be assumed to take the value

$$\frac{ASFR(0,a)}{C_c(0,a).C_m(0,a).C_a(0,a)} \cdot \frac{C_i(t)}{C_i(o)}$$

which is a slowly increasing function of t as already mentioned in section 2.

We can call the ratio (3.7) as the age-specific natural fertility rate.

Extensive studies made by Coale, Trussell and others have shown that age-specific values of natural fertility, when expressed in relative terms, exhibit a fairly steady pattern. In fact, the overall sterility correction factor has been estimated from the age-specific factors by assuming that the Coale - Trussell pattern of natural fertility is applicable to developing countries. Of course, we need not stick to this pattern alone and can try out a variety of patterns. A big advantage is that these patterns can be specified in an exogenous manner. In our opinion, it would be methodologically preferable to use these (exogenous) values of natural fertility (expressed in relative terms and in different patterns) to complete the package of inputs (depleted due to non-inclusion of ASFR's). In this way, by identifying an alternative to the use of ASFR's as an input in the model, we have demonstrated not only the validity of our criticism but also the constructive nature of our approach and comments.

4. A MODIFIED VERSION OF THE FERTILITY MODEL

We have attempted, in this section, to modify the population council's fertility model so as to remove the deficiencies that we pointed out and discussed in the previous section.

Our model consists of three blocks. Within each block, there are several steps.

The three blocks are:

I. Base year consistency - searching block

II. Target year aggregate modelling block

III. Target year age-specific set-estimation block.

A brief description of each block follows, along with theoretical justification wherever new formulas are introduced.

4.1 Base year consistency - searching block

The objective of this block is to put together bench mark data and estimates for a base year and to check internal consistency between the following:-

a) Age-specific contraceptive prevalence rates and the overall CPR;

b) Age-specific fertility rates;

c) Total population, number of all women in five yearly age groups, and MWRA in five yearly age-groups;

d) Total fertility rate;

e) Crude birth rate;

f) Relative values of age-specific natural fertility rates.

The year 1981 is taken as the base year because the population census as well as a contraceptive prevalence survey (CPS-81) was conducted in that year. Bench-mark data and estimates for items (a) and (c) are provided by these two sources.

Estimates for items (d) and (e), that have been made for 1981 by different organisations, lie within a narrow range, and have thus received wide acceptance.

The situation about items (b) and (f) is not so clear. We have therefore experimented with different sets of values of (f), which, along with (a), (c), (d) and (e) as provided by the above-mentioned sources, yield estimates of (b).

Once we have found (f) which, together with (a) to (e), broadly satisfy conditions of internal consistency for 1981, the same (f) can be used as an input for making projections for subsequent years. While making consistency checks, we have to be prepared to allow for a reasonable margin of error, because demographic data and estimates in Bangladesh cannot be expected to be error free. Also, we have to choose between two possible checks of consistency, namely

(i) overall CPR and unweighted average of age-specific CPR's, i.e. whether u is equal to $1/7 \sum u_i$. Bongaarts and Potter (1983) have suggested this.

(ii) overall CPR and weighted average of age-specific CPR's, i.e. whether (MWRA).(u) is equal to $\sum$ $(MWRA_i).(u_i)$. This can be called consistency in regard to "users" of

contraceptive methods. Both these cannot be fulfilled at the same time. We have chosen the latter in this monograph.

A key question is, how accurate are the estimates of age-specific CPR's as well as of overall CPR as given by the 1981 contraceptive prevalence survey ? We can only say that, after some adjustments [which we shall indicate], the results of CPS-81 are believed to be fairly accurate, and that they do not significantly daviate from trend based values as provided by similar surveys for recent years. However, our model is not rigidly tied to any particular set of values. If the CPS 1985-86 shows a different pattern, then the same type of experimentation can be performed for 1985-86 as we have done for 1981. But our model does need bench-mark data and estimates for a base year which satisfy internal consistency checks and provide sets of relative values of age-specific natural fertility rates.

Another obvious question is, why not accept relative values suggested by Coale and Trussell for developing countries in general ? We feel we should start with these values, but need not blindly accept any international pattern unless it has been tested for validity for Bangladesh. This country is large enough to justify a search for a national pattern which may or may not be similar to an internatinonal pattern. Therefore, we have experimented with the Coale-Trussell pattern as well as other patterms.

Having clarified the underlying purpose of the base year consistency-searching block, we now give a step by step account thereof.

Step-1

Use CPS-1981 to derive overall CPR as well as age-specific CPR's by adjusting for suspected under-reporting of male methods. The CPS-1981 gives an unadjusted overall CPR equal to 0.186. However, it is suspected that the women respondents did not fully report male methods (Vasectomy and condom use). Similar under-reporting was noticed in CPS-1983, as estimate of which was made possible by the results of the couple-sample. Since no couple-sample was conducted in 1981, the rate of female under-reporting of male methods found in 1983 was applied to 1981 also. The overall CPR in 1981, adjusted in this manner, works out to be 0.209, and an age-wise breakdown of this is shown below:-

Age-group	15-19	20-24	25-29	30-34	35-39	40-44	45-49
CPR	0.101	0.195	0.256	0.274	0.246	0.243	0.125

Step 2

Take the data of 1981 population census and adjust it for under-enumeration to obtain total population, and age-wise figures of AWRA and MWRA, for example,

Total population (adjusted) in thousands = 89,915

AWRA (adjusted) in thousands = 18,923

MWRA (adjusted) in thousands = 15,895

Index of marriage C_m = 0.840

(Age-wise estimates are available on computer).

Step 3

Use the formula of the aggregate model to calculate what we call (for convenience) "Non-contraceptors aquivalent adjusted for sterility and other factors" (N).

N = Total MWRA (1-sue). C_a .....(4.1)

where s = overall sterility correction factor = 1.08

u = 0.209 (from step 1)

e = average use-effectiveness of contraceptive method mix which is estimate4d to be 0.84.

C_a = overall index of induced abortion(0.9849).

Value of N for 1981 comes to 12,687.

Step 4

Experiment with different sets of relative values of age-specific natural fertility rates, and calculate TFR and CBR from each set.

ASNFR = Age-specific natural fertility rates

$$= \frac{1}{5} \frac{\text{Relative value of age-group}}{\text{Sum of relative values}} \cdot TFR \cdot \frac{AWRA}{N} \quad ....(4.2)$$

Births to women in each age-group= $B_i = ASNFR_i \times MWRA_i \times (1 - s_i u_i e_i) \times C_{ai}$ ..(4.3)

where s_i = sterility correction factors for the seven age-groups namely 1.02, 1.02, 1.03, 1.04, 1.12, 1.33 and 2.08 as suggested by the Population Council.

u_i = age-specific CPR's derived from CPS-81 and adjusted as in step 1.

e_i = age-specific use-effectiveness. Since the overall e =

0.84, values for age-groups below 30 may be taken to be 0.83, while those above 30 may be assumed to be 0.8475.

c_{ai} = age-specific index of induced abortion. Since the overall index = 0.9849, values for the younger ages can be assumed to start from 0.97, rising slowly with age and going up to one.

$$ASFR_i = \frac{B_i}{AWRA_i} \text{ for each age group} \qquad \ldots.(4.4)$$

$$CBR = \frac{1000}{P} \sum B_i \qquad \ldots(4.5)$$

$$TFR = 5 \sum ASFR_i \qquad \ldots..(4.6)$$

Based on experimentation, select those sets of relative values of age-specific natural fertility rates which yield CBR close to the commonly accepted value of 42.0, and TFR close to the commonly accepted value of 6.3. The results can be summarized in the following form:-

Relative values of natural fertility according to age group

	Pattern I	Pattern II	Pattern III	Pattern IV
15-19				
20-24				
25-29				
30-34				
35-49				
40-44				
45-49				
Est. of TFR				
CBR				

Specific data and estimates will be presented in section 5.

4.2 Target year aggregate modelling block

The objective of this block is to apply the Population Council's aggregate fertility model for the target year, and to estimate the overall CPR needed to achieve the TFR target. With the help of the overall CPR, the total number of "non-contraceptors' equivalent (adjusted for sterility and other factors) can be estimated. These will prove to be useful inputs for the target year age-specific set-estimation block.

Step 1

Make assumptions for the overall values of C_m, C_a and C_i for the target year which take into account likely changes between the base year and the target year.

Having taken 1981 as the base year, we shall consider four different target years, namely, 1986, 1991, 1996, and 2001.

Assumption regarding C_m : According to the 1981 population census, currently mazrried women constituted 84% of all women in the age-group 15-49. This means C_m for 1981 was equal to 0.840. A common assumption for Bangladesh is that the average age at marriage is gradually increasing. Therefore the value of C_m can be assumed to decrease by 0.005 after every five years, as shown below:-

Year	Assumed value of C_m
1981	0.840 (given by census)
1986	0.835
1991	0.830
1996	0.825
2001	0.820

Assumption regarding C_a : The Population Council's formula for estimating the index of ineduced abortion is

$$C_a = \frac{TFR}{TFR + 0.4 \times (1 + \text{overall CPR}) \times \text{Total induced abortion rate.}} \quad ...(4.7)$$

This formula for C_a needs prior knowledge of overall CPR, but tne formula for CPR also needs prior knowledge of C_a. To bypass tha circularity problem, the overall CPR can be approximately calculated by assuming that $\frac{C_a(t)}{C_a(0)} = 1$. This is justified because changes in CPR in Bangladesh are linked primarily with changes in TFR, and C_a has no major role.

Total induced abortion rate can be assumed to be 0.2 for each of the four target years.

This implies the following:-

Year	TFR target	Assumed value of C_a
1986	5.6	0.9818
1991	4.8	0.9772
1996	4.2	0.9725
2001	3.6	0.9664

Assumption regarding C_i : The Population Council's formula for estimating the index of postpartum infecundability is

$$C_i = \frac{20}{18.5 + \text{Duration in months of postpartum infecundability}} \quad \ldots (4.8)$$

However, there are no reliable and consistent data on breast-feeding in Bangladesh.

The following assumptions about C_i help in avoiding serious problems of inconsistency:-

Year	Assumed value of C_i
1986	0.6237
1991	0.6315
1996	0.6450
2001	0.6559

Step 2

Estimate the overall CPR needed to achieve the TFR target.

The relevant formula is

$$u(t) = \frac{1}{1.08 \times e(t)}\left[1 - \frac{C_m(0)\ C_e(0)\ C_i(0)\ C_c(0)\ TFR(t)}{C_m(t)\ C_e(t)\ C_i(t)\ TFR(0)}\right] \quad ..(4.9)$$

The following estimates are obtained:-

Year	TFR target	e	u
1986	5.6	0.883	0.298
1991	4.8	0.897	0.400
1996	4.2	0.900	0.483
2001	3.6	0.900	0.563

Step 3

With the help of the estimated overall CPR, calculate the total number of "non-contraceptors equivalent" [adjusted for sterility and other factors] for each of the target years.

The formula is

$$N = MWRA\ (1 - s.u.e)\ .\ C_e \quad .....(4.10)$$

The following estimates are obtained:-

Year	Overall s	Overall N [in thousands]
1986	1.08	13,364
1991	1.08	13,717
1996	1.08	13,626
2001	1.08	12,939

When we move from aggregate modelling to age-specific estimation, three of the factors considered in this block, namely C_m, CPR, and C_e will need to be decomposed by age. However, the index C_i can be assumed to be age-invariant. Non-inclusion of this in the age-specific estimation procedure helps in simplifying the formulas.

4.3 Target-year age-specific set-estimation block

This is the final and the most important block of our model. We have attempted in this block to remove the deficiencies that we pointed out in the Population Council's model. The first two blocks of over model have paved the way and prepared the background to enable us to introduce three new elements in this block which we have designated "a trend regulator", "a program re-allocation factor" and "a deflator". However, we shall continue with a step-by-step description till we arrive at the right spot where the new factors have to be introduced.

Step 1

Bring together in one place the following inputs for each of the target years:-

(a) Total population, number of all women in five yearly age-groups, and MWRA in five yearly age-groups;

(b) TFR target;

(c) Overall CPR needed to achieve the TFR target as estimated in block 2, step 2;

(d) Estimated total number of "non-contraceptors equivalent" adjusted for sterility and other factors" (reference block 2, step 3);

(e) Relative values of age-specific natural fertility rates (Take all acceptable sets of such values as derived for the base year in block 1, step 4).

In addition, keep for ready use,

(f) Age-specific contraceptive prevalence rates and the overall CPR for the base year (1981) as derived in block 1, step 1.

As regards the inputs (a), the overall estimates are the following:-

Target Year	Total popueltion (000)	AWRA (000)	MWRA (000)
1986	101,553	22,775	19,017
1991	113,358	27,612	22,918
1996	125,804	32,012	26,410
2001	137,904	36,064	29,572

Age-specific estimates are available on the computer.

As regards inputs (b) to (d), all the values for the target years are available in block 2.

Regarding input (e), we shall use for the target years the same patterns of age-specific natural fertility which have been experimented upon for the base year. These are available in block 1, step 4.

Finally, the inputs (f) for the target years are, really speaking, base year values of the contraceptive prevalence rates, already available in block 1, step 1. These will occur in the formula for the corresponding estimates for the target years, as we shall explain.

Step 2

Calculate age-specific natural fertility rates for each target year by means of the formula

$$ASNFR = \frac{1}{5}\frac{\text{Relative value for age-group}}{\text{Sum of relative values}} \times TFR. \frac{AWRA}{N} \quad ..(4.11)$$

where N is already estimated in block 2, step 3.

Obviously, each set of relative values will yield one set of ASNFR for each target year, but their sum (multipjlied by 5) will be the same for each year, namely the total natural fertility rate (TNFR).

Check that $5 \sum ASNFR = TNFR$ in each case.

Step 3

This step relates to estimating age-specific CPR's for each target year. However, a scientific way of deriving a suitable formula for this purpose needs to be explored and identified. This can be done in the following manner.

The most important part of the model is a formula which expresses age-specific CPR's, i.e., $u_i(t)$ for each target year as a function of the following:-

(a) the corresponding age-specific CPR's in the base year, i.e., $u_i(0)$;

(b) the overall CPR in the target year, i.e. $u(t)$ already estimated to be necessary for achieving a TFR target. The functional relationship between $u_i(t)$ and $u(t)$ should be such that the average of the seven $u_i(t)$ values yields $u(t)$. This is an important consistency condition;

(c) the overall CPR in the base year, i.e., $u(0)$. Again, it is necessary that the $u_i(0)$ and $u(0)$ appear in the formula for $u_i(t)$ in such a way that they cancel each other when the seven $u_i(t)$ values are averaged to obtain $u(t)$ because otherwise the consistency condition stated in (b) above

would not be fulfilled. We can term this as another consistency condition.

The simplest formula that fulfils the above-mentioned requirements is

$$u_i(t) = u_i(0) . \frac{u(t)}{u(0)} \qquad \ldots\ldots(4.12)$$

which increases each $u_i(0)$ in the same proportion. In the averaging process, the ratio $\frac{u_i(0)}{u(0)}$ becomes one, and consistency is achieved. But it should be noted that the values obtained in this way are not to be considered as unique, because formula (4.12) is only one of the many possible formulas that can be thought of, as we shall see later.

The $u_i(t)$ values obtained by formula (4.12) can be expected to be consistent with the TFR target because u(t) was derived from TFR. But we have to check what the corresponding CBR is. For this purpose, we use the following formulas:-

$$N_i(t) = MWRA_i(t)\ [1-s_i(t).u_i(t).e_i(t)]C_{ai}(t)$$

$$B_i(t) = N_i(t).ASNFR_i(t)$$

$$CBR(t) = \frac{1000}{P(t)} \sum B_i(t)$$

Let us assume, for purposes of avoiding unwarranted optimism, that the CBR obtained in this way is found to be different from what has been specified as a target. In that case, either the CBR-target or the TFR target needs to be revised, or, if that raises other difficulties, a way should be found to re-adjust formula (4.12).

Theoretically, what we need is a formula which contains a "trend regulator" whose values can be adjusted so as to be consistent not only with a TFR target but also with a CBR target.

This can be considered as consistency condition (d), to be tagged on to conditions (b) and (c) already specified above.

We have devised a formula which is more general than (4.12) in the sense that it contains (4.12) as a special case but which is capable of yielding other values also in an attempt to achieve simultaneous consistency with TFR and CBR targets.

The new formula is

$$u_i(t) = u_i(0) + [u(t)-u(0)] + R[u_i(0)-u(0)] \qquad \ldots\ldots(4.13)$$

where the "trend-regulator" R can take values between -1 and $\frac{u(t)}{u(0)} - 1$. In fact, if $R = \frac{u(t)}{u(0)} - 1$, then formula (4.13) collapses into formula (4.12).

The consistency conditions (b) and (c) are satisfied by formula (4.13), because for any value of R within the specified range, the average of the right hand terms is u(t), since the mean of $u_i(0)$ is u(0). Consistency with TFR is thus retained.

However, there is still no guarantee that any of the sets of values obtained from formula (4.13) by choosing R will help in achieving consistency with a given CBR target. What we have gained is that chances of a simultaneous consistency with TFR and CBR are increased by using (4.13) instead of (4.12). The situation when R fails to achieve such simultaneous consistency will be examined later. For the present, we want to explore further what R is capable of doing.

When R = -1, the formula (4.13) is reduced to

$$u_i(t) = u(t) \qquad \ldots\ldots(4.14)$$

which means uniformity of CPR's in all the age-groups. This is obviously a limiting case which may neither be feasible nor

desirable. However, it is useful to note that negative values of R represent a shift from an inverted U-shaped distribution of CPR's in the base year towards a uniform distribution in the target year.

When R = 0, the $u_i(t)$ values represent another U-shaped curve, parallel to the one depicting base year values.

The case of the other extreme value $R = \frac{u(t)}{u(0)} - 1$ has already been referred to above, since (4.13) then becomes identical with (4.12). In this case, each value of CPR in the target year is obtained by multiplying the corresponding base year value by the same number (1+R). Such a procedure can become unrealistic in the long run. For example, the highest age-specific CPR value in 1981 was 0.2740 (after adjustment) which would go up to nearly 0.74 in the year 2001 by this formula. Such a concentration of effort in any particular age-group calls for a more weighty justification, based on a recent evaluation, and not simply because CPR in that age-group was high in the base year.

The upshot of the above reasoning is that if the age-specific CPR values, projected by formulas (4.12) or (4.13) fail to achieve simultaneous consistency with TFR and CBR, then the direction as well as the content of the entire family planning program should be scientifically evaluated. Such an evaluation may be necessary for other reasons as well, but it should, among other things, help in identifying a strategy for bringing about a desired reduction in CBR.

On theoretical considerations, we can say that the most effective way of reducing CBR through contraception is to

concentrate attention on those age-groups where fertility is the highest. Although we cannot know in advance the values of ASFR's in the target year, we still have an option based on age-specific natural fertility rates (ASNFR's), since these have been estimated by us for the target year, in block 3 step 2 above.

According to the standard Coale-Trussell pattern, which we have used (with as well as without modification), the ASNFR's are the highest in the age-groups 20-24 and 25-29. As compared to this, the age-specific CPR-values in the base year 1981 were the highest for the age-groups 30-34 and 25-29. This helps us understand why the $u_i(t)$ values derived from formula (4.12) or (4.13) may not be up to the mark. A pro-rata intensification of effort guided by base year CPR values alone would not attach as much importance to age-groups 20-24 and 25-29 as would be justified by the highest fertility levels in these age-groups.

In order to rectify the situatiion, we need to introduce a "program reallocation factor" which can make $u_i(t)$ a function of $ASNFR_i(t)$ in such a way that $u_i(t)$ can be particularly increased for those age-groups in which the estimated $ASNFR_i(t)$ are the highest. This may appear to complicate further the formula for $u_i(t)$, but there is ample theoretical justification for this.

We have devised a "program reallocation factor" (PRF), an unadjusted form for which is given by the equation

$$PRF_i(t) = \exp\left(K \times \left[\frac{35\ ASNFR_i(t) - TNFR(t)}{10}\right]\right) \qquad \ldots\ldots\ldots(4.15)$$

where K can take values between 0 and 1. We have to clarify why

we have chosen a function of this type.

For each target year, the function PRF takes on seven values, one for each five yearly age-group, starting from 15-19 and going up to 45-49. For K=0, all the values of PRF are equal to one, since exp(0) = 1. This means that K=0 represents a situation where no reallocation of the program is necessary.

When K>0, the value of PRF is highest for those age-groups for which $ASNFR_i(t)$ are the highest, that is, for age-groups 20-24 and 25-29.

The expression within parentheses, namely

$$35 \times ASNFR_i(t) - TNFR(t) \qquad \ldots\ldots(4.16)$$

is such that its average value for the seven age-groups is zero because

$$5 \sum_{i=1}^{7} ASNFR_i(t) = TNFR(t)$$

An expression with an average zero value is necessary, because otherwise the $u_i(t)$ estimated thereby would not average out to u(t). In fact, although the average value of (4.16) is zero, the average value of (4.15) is slightly more than one, because of the characteristic properties of the exponential function. Therefore, the unadjusted form (4.15) has to be suitably "deflated" to achieve the final form

$$PRF_i(t) = \frac{1}{1+DK} . \exp\left(K \left[\frac{35\ ASNFR_i(t) - TNFR(t)}{10}\right]\right) \qquad \ldots\ldots(4.17)$$

where D is an "exponential average deflator" and K as well as D can take values between 0 and 1.

Combining (4.13) and (4.17), the formula for estimating the age-specific CPR's for the target year is

$$u_i(t) = [u_i(0) + (u(t)-u(0)) + R(u_i(0)-u(0))] \times \frac{1}{1+DK} \exp\left(K\left[\frac{35\ ASNFR_i(t) - TMFR(t)}{10}\right]\right) \quad .....(4.18)$$

We have put forth theoretical considerations which make it necessary to introduce three separate parameters, R, K and D. The parameters R and K operate through different sets of variables, and their main effect is also on different age-groups. It would be difficult to achieve through any single parameter (either R or K or any new one) what the two together can do. The third parameter D ensures consistency of the u_i values with the overall u. The practical utility of the R-K-D combin tion will be illustrated by applying the model to Bangladesh data.

It has been assumed as a pre-condition for our age-specific model that u(t) has been estimated by the Population Council's aggregate model. It is implied therefore that any increases of $u_i(t)$ in selected age-groups are accompanied by eq ivalent slackening of effort in the other age-group. Such a selective approach is particularly needed for Bangladesh because the initial acceptors of contraception were mainly those who had already had the desired number of children. The median age of such (female) acceptors was over 30. In future, the age-groups 20-24 and 25-29 will deserve greater attention if fertility reduction targets are to be achieved. Many of these acceptors will practice temporary methods of contraception for spacing of births rather than seek birth-terminatinon through permanent methods. All such issues are symbolically quantified through an R-K-D combination which is also intended to measure the degree of effort involved in bringing about the necessary changes in the program.

At this stage, a graphical description of how R and K effect the shape of the $u_i(t)$ curve by age may facilitate further clarification of our argument. For this purpose, we need not consider D because its role is only for achieving consistency between the $u_i(t)$ values and the overall $u(t)$, and not for changing the shape of the $u_i(t)$ curve.

In figure 4.1, the base-year $u_i(0)$ values have the shape of an inverted U-distribution, with its peak in the age-group 30-34.

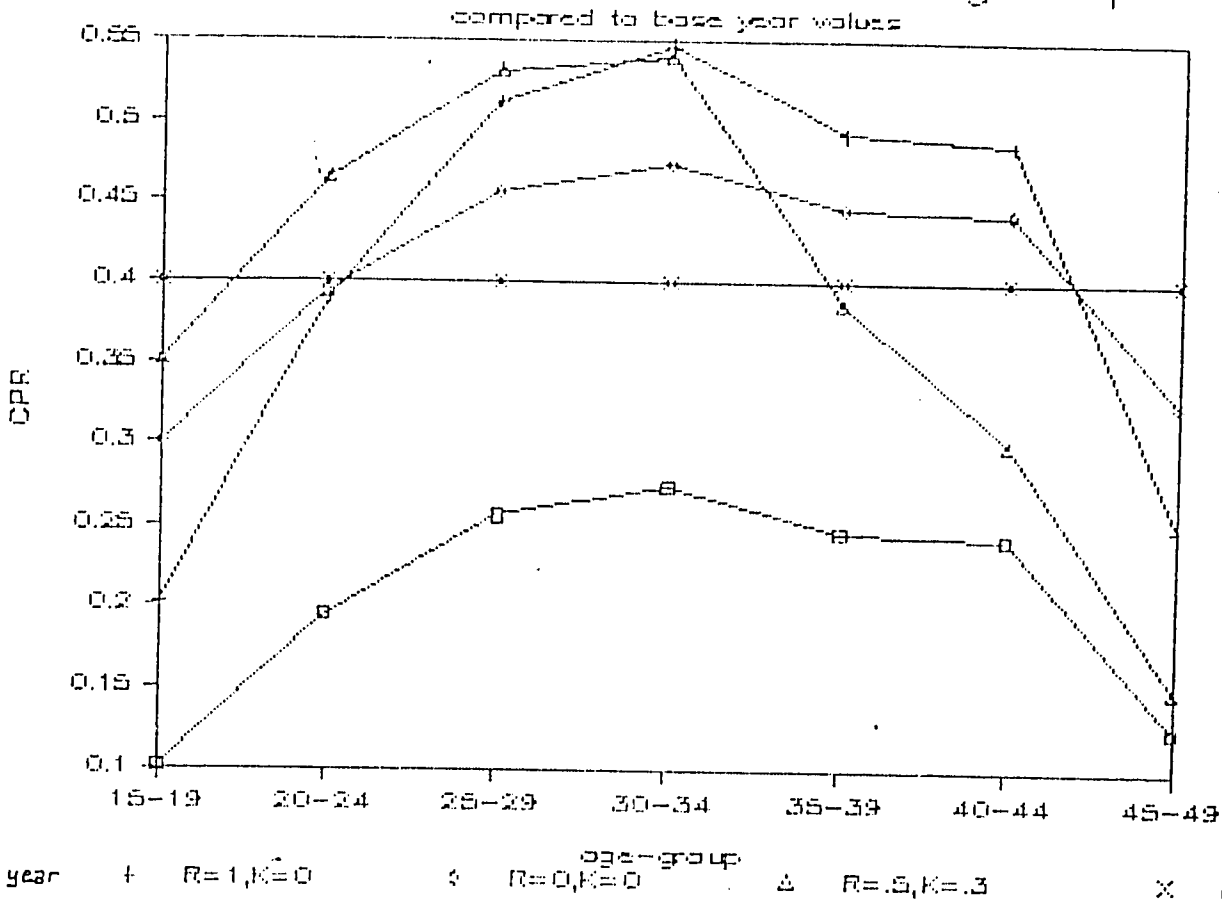
For R=0, the target year $u_i(t)$ values are on a higher curve which is parallel to the base year curve.

For $R = \frac{u(t)}{u(0)} - 1$, each value of $u_i(0)$ is multiplied by 1+R, which means that the highest values in the base year attain a new high peak, due to proportionate increase in the target year. Such a new high peak may be neither necessary nor feasible, but we show it as a limiting case.

For R = -1, all $u_i(t)$ values become equal.

Now, the role of K is to change the shape of the $u_i(0)$ curve and tilt it in favour of the age-groups 20-24 and 25-29 in the target year. Such a transformation in the shape of the curve cannot be achieved by R, because R takes for granted the shape of the $u_i(0)$ curve with its peak corresponding to age 30-34. Contrary to this, K favours those age-groups in which age-specific natural fertility rates are the highest. Only by such a shift can we hope to achieve new $u_i(t)$ values which can reduce the number of births at a faster rate than would be otherwise possible. Of course, all such shifts have to be within limits of feasibility,

Fig.4.1:R & K's influence on age-spCPRs



□ Base year + R=1,K=0 ◇ R=0,K=0 △ R=.5,K=.3 × R=-1, K=0

which correspond to the ranges of permissible values of R and K in our model.

After giving theoretical justification for our basic formula (4.18), we can now say that step 3 of this block consists in applying this formula to estimate age-specific CPR's for each target year. Corresponding to each pattern of natural fertility, an R-K-D combination is selected, through a self-devised computer program, so as to obtain estimates of TFR and CBR (as close as possible to the targetted or commonly accepted values), subject to the overall consistency condition, namely that

$$\sum_{i=1}^{7} MWRA_i(t) \times u_i(t) = MWRA(t) \times u(t) \qquad \ldots\ldots(4.19)$$

Step 4

Estimate births to women in each age-group by the formula

$$B_i(t) = MWRA_i(t)[1 - s_i . u_i(t) . e_i(t)] . C_{ai}(t) . ASNFR_i(t) \qquad \ldots\ldots(4.20)$$

The $u_i(t)$ estimated in step 3 are used as inputs to step 4.

Step 5

Estimate CBR, ASFR and TFR by means of the formulas

$$CBR = \frac{1000}{P} \sum B_i \qquad \ldots\ldots(4.21)$$

$$ASFR_i = \frac{B_i}{AWRA_i} \qquad \ldots\ldots(4.22)$$

$$TFR = 5 \sum ASFR_i \qquad \ldots\ldots(4.23)$$

Formula (4.22) shows that ASFR(t) form part of the outputs in our model.

Finally, we can say that our formula (4.18) is so powerful that it can provide estimates of $u_1(t)$ that are needed to achieve (by means of subsequent formulas 4.20 to 4.23) simultaneous consistency with TFR and CBR targets, provided of course that the targets themselves are reasonable. In fact, any value of TFR and/or CBR, which is not obtained within the stipulated range of values of R, K and D can be considered unrealistic. It goes without saying that only feasible values of TFR and CBR can be simultaneously fitted to our model which ensures internal consistency by means of formula (4.19).

All this will be illustrated by applying the model to Bangladesh data in section 5.

5. APPLICATION TO BANGLADESH AND NEW RESULTS OBTAINED

Although the model presented in the previous section can be theoretically relevant to any country where rising rates of contraceptive prevalence are considered an important tool for fertility reduction, the inspiration for building the model has come from a careful study of the demographic situation in Bangladesh. Therefore, in this section we concentrate our attention on applying the model to Bangladesh.

To start with, we have to select a base year for which we have fairly reliable data or estimates relating to the following:-

(a) Total population of the country (P);

(b) Number of all women (AWRA), and currently married women (MWRA), in five yearly age-groups, starting from 15-19 and going up to 45-49;

(c) Age-specific contraceptive prevalence rates, and the overall average rate (CPR or u);

(d) Age-specific average use-effectiveness of contraceptive methods, and the overall average (e);

(e) Age-specific sterility correction factors, and the overall average (s);

(f) Age-specific indices of induced abortion (C_{as}) and the overall index (C_a);

(g) A firm estimate of TFR or a reasonable TFR target.

In addition, it is useful to have a fairly reliable estimate of the following:-

(h) Overall index of postpartum infecundability which can be derived from average duration of breast feeding (C_i).

At the moment, the obvious choice for the base year is 1981, since the latest population census was conducted in that year and a contraceptive prevalence survey (CPS-81) was also conducted in the same year.

For purposes of our model, we need one more input, namely,(i) Age-specific natural fertility pattern, expressed in relative terms (Since this is an underlying pattern, it should be applicable to the base year as well as to the target years).

So far, this aspect has not received much attention in Bangladesh and no standard pattern of natural fertility is commonly accepted for this country. For developing countries in general, a standard pattern was formulated by Coale and Trussell (1974).

We have therefore experimented with many possible patterns of natural fertility, and finally chosen the following four:-

Pattern I : Coale-Trussell pattern (without any modification);

Pattern II : Coale-Trussell pattern, modified for ages over 40;

Pattern III : Coale-Trussell pattern, modified for ages over 40 and below 20;

Pattern IV : Completely different from Coale-Trussell.

Since we have a self-devised computer program, we can easily experiment with additional patterns. We have found, however, that the four patterns selected by us provide a fairly wide choice, and any new pattern is unlikely to make a significant impact on the broad range of results that we have obtained by using Patterns I to IV.

Corresponding to each pattern of natural fertility, five main outputs have been obtained for the base year 1981 which are specified below along with the relevant formulas:-

(i) Age-specific natural fertility rates (ASNFR)

$$ANSFR = \frac{1}{5} \frac{\text{Relative fertility value}}{\text{Sum of these values}} \text{(TFR target)} \frac{AWRA}{MWRA(1-sue).C_a} \quad \ldots(5.1)$$

Overall u in the base year is used as an input here.

(ii) Births to women in each age-group (B_i)

$$B_i = ASNFR_i \times \text{married women in age-group}_i (1-s_i u_i e_i).C_{ae} \quad \ldots(5.2)$$

Base year u_i's are an input for our model, as well as $ASNFR_i$ estimated in the previous step.

(iii) Age-specific fertility rates ($ASFR_i$)

$$ASFR_i = \frac{B_i}{\text{All women in that age group}} \quad \ldots\ldots(5.3)$$

B_i's estimated in the previous step are used as an input for this step.

(iv) Estimate of crude birth rate (CBR)

$$CBR = \frac{1000 \times \text{total births } B}{\text{Total population } P} = \frac{1000 \sum B_i}{P} \quad \ldots(5.4)$$

(v) Estimate of total fertility rate (TFR)

$$TFR \text{ (estimate)} = 5 \sum ASFR_i \quad \ldots\ldots(5.5)$$

This estimate could be different from the TFR target used as an input for step (i) above. However, we have selected the

fertility patterns II to IV which yield TFR estimates close to TFR target.

Appendix tables A.1 to A.4 summarize the main inputs as well as the main outputs for the base year 1981.

The primary purpose of experimenting with different fertility patterns is to see whether their use (along with other inputs) provides a reasonable fit to Bangladeshi situation in 1981, and if so, which of these patterns can be expected to yield the most reliable results. For this purpose, we compare below the estimates of TFR and CBR given by the four patterns with the commonly accepted values of these rates for 1981:-

	Pattern I	Pattern II	Pattern III	Pattern IV	Commonly accepted value
Estimate of TFR for 1981	6.42	6.38	6.41	6.50	6.3
CBR	43.68	42.83	42.83	44.21	42.8

We find that pattern II provides the best fit, closely followed by pattern III. These patterns are modified variants of the standard Coale-Trussell formulation.

We need not take the view that patterns I and IV are unsuitable, since the commonly accepted values themselves might be subject to a margin of error.

It seems advisable to carry on with all the four patterns for each of the target years, namely 1986, 1991, 1996 and 2001.

However, before we do so, we would like to draw attention to the base year value of the "total natural fertility rate" (TNFR)

for which the relevant formula is

$$TNFR = 5 \sum ASNFR_i \qquad \ldots\ldots(5.6)$$

All the tables A.1 to A.4 yield the same value of TNFR for 1981, namely, 9.3966, which can be rounded to 9.40.

One final comment may now be made about the estimates of the various indices for the base year 1981. In the terminology of the Population Council,

$$C_m = \text{Index of marriage} = \frac{MWRA}{AWRA} = 0.84$$

$$C_c = \text{Index of contraception} = 1 - sue = 0.8104$$

C_c = Index of induced abortion.

$$= \frac{TFR}{TFR + 0.4\ (1+u) \times \text{Total abortion rate}} = 0.9849$$

For the index of postpartum infecundability (C_i) there is no commonly accepted value for Bangladesh. We therefore suggest that this index for 1981 should be estimated from the formula

$$C_i = \frac{TFR}{15.3 \times C_s \times C_c \times C_m} = 0.6142$$

The number "15.3" in the denominator of the formula for C_i is "total fecundity rate" for which, we have assumed the general value recommended by Bongaarts & Potter (1983), in the absence of any specific estimate for Bangladesh.

Now we can proceed to apply our model for the target years

1986, 1991, 1996 and 2001. We have devised a seperate computer program for this purpose, because the inputs are now different from those used for the base year, and the outputs are also different.

For every target year, the inputs are the following:-

(a) Natural fertility pattern (the same four patterns as used for 1981);

(b) Total population in the target year (P);

(c) Number of all women (AWRA) as well as currently married women (MWRA) in five-yearly age-groups, starting from 15-19 and going up to 45-49 (to be estimated on the assumption that the percentage of currently married women to total women in ages 15-49 is slowly going down due to rising age at marriage).

(d) TFR target and overall CPR or u needed to achieve that target as estimated from the aggregate model;

(e) Sterility correction factor (s).

Theoretically, the overall sterility correction factor (1.08) has been derived from the age-specific factors on the assumption that the underlying natural fertility pattern is that suggested by Coale and Trussell which is pattern I in our model. Similar calculations made for patterns II to IV in our model yield the overall values as 1.09, 1.09 and 1.07. Since these values are fairly close to the standard value 1.08, we have not made any adjustment regarding this for patterns II to IV.

[f] Use-effectiveness of contraceptive methods [e]

The overall value of e can be assumed to rise from 0.84 in 1981 to 0.9 by 1996, and then stay at that level through 2001. The age-specific values in ages below 30 are slightly lower than those in ages over 30. For each target year, values consistent with these have been assumed for inclusion in the package of inputs.

[g] Age-specific contraceptive prevalence rates in the base year [$u_i[0]$] as well as the overall value in the base year [u[0]]. Such values for the base year 1981 are needed as inputs for using formula [4.18].

[h] Trend-regulator R

R can be assighed any value between -1 and $\frac{u[t]}{u[0]} - 1$. Since u[t] varies for each target year, the upper limit of R also varies, for example it is 0.4258 for 1986, 0.9139 for 1991, 1.3110 for 1996 and 1.6938 for 2001.

[i] Program re-allocation factor K

K can be assigned any value between 0 and 1.

[j] Exponential average deflator D.

D can be assigned any value between 0 and 1. In fact, a self-devised computer program helps us in identifying an R-K-D combination which yields estimates of TFR and CBR close to commonly accepted target values, subject to the consistency condition

$$\sum MWRA_i . U_i = MWRA \times u$$

Corresponding to each pattern of natural fertility, six main outputs have been obtained for each target year, which are specified below along with the relevant formulas:-

(i) Age-specific natural fertility rates

$$ASNFR = \frac{1}{5} \frac{\text{Relative fertility value}}{\text{sum of these values}} (TFR\ target) \frac{AWRA}{MWRA(1-sue).C_s} \quad \ldots\ldots(5.7)$$

Overall u needed to achieve TFR target is an input for our model.

(ii) Age-specific contraceptive prevalence rates $u_i(t)$.

The relevant formula (4.18) is already given in the previous section. The ASNFR's obtained as outputs above are used as inputs in this formula. Another input here is TNFR which is equal to 5 Σ ASNFR.

(iii) Births to women in each age-group (B_i)

B_i = $ASNFR_i$ x married women in $\text{age-group}_i.(1-s_i u_i e_i).\ C_{ae}$

Target year u_i's, which are estimated in the previous step, are used as an input for this step. C_{ae} are the age-specific indices of induced abortion.

(iv) Age-specific fertility rates

Since, $ASFR_i = \frac{B_i}{AWRA_i}$, the values of B_i obtained as outputs above are used as inputs here.

(v) Estimate of Crude birth rate

$$CBR = \frac{1000}{P} \Sigma B_i$$

(vi) Estimate of Total Fertility Rate (TFR)

TFR (estimate) = 5 Σ $ASFR_i$

This estimate could be different from the TFR target used as an input for step (i) above.

Appendix tables A.5 to A.20 summarize the main inputs as well as the main outputs for the target years 1986, 1991, 1996 and 2001.

At this stage it would be convenient to bring together in one place all the estimates of TFR and CBR contained in Tables A.5 to A.20. This is presented in summary Table 5.1.

Summary Table 5.1

Estimates of TFR and CBR for 1986, 1991, 1996 and 2001 under four variants

Variant	Natural fertility pattern	TFR estimates 1986	TFR estimates 1991	TFR estimates 1996	TFR estimates 2001	CBR estimates 1986	CBR estimates 1991	CBR estimates 1996	CBR estimates 2001
I	Coale-Trussell	5.63	4.70	4.16	3.51	40.02	36.92	33.50	30.08
II	Coale-Trussell modified for ages over 40	5.63	4.71	4.11	3.47	39.38	36.36	33.86	29.42
III	Coale-Trussell modified for ages over 40 & below 20	5.64	4.71	4.13	3.50	39.20	36.19	33.91	29.62
IV	Completely different from Coale-Trussell	5.64	4.71	4.08	3.56	39.75	36.50	34.18	30.18
Range given by the highest and lowest estimates for each target year		5.63 5.64	4.70 4.71	4.08 4.16	3.47 3.56	39.20 40.02	36.19 36.92	33.50 34.18	29.42 30.18

The main conclusions that we can draw from the above sets of estimates are the following:-

- TFR estimates for the years 1986 to 2001, which are currently used, appear to be reasonable;
- CBR estimates for 1986 and 1991, which are currently used, seem to be under-estimates, particularly for 1991;
- CBR estimates for 1996 and 2001, which are currently used, appear to be reasonable.

A special (and new) feature of our results is that they have been obtained by a single, integrated model which takes into account inputs like the base year contraceptive prevalence rates (but not the target year ASFR's), and which yields all the desired outputs including target year contraceptive prevalence rates, ASFR's, TFR and CBR. Underlying the model are values of age-specific natural fertility rates, expressed in relative terms, in respect of which we have experimented with several patterns. The fact that our model, with the help of self-devised computer programs, can repeat the entire exercise with a new base year as well as with any new pattern of natural fertility gives us confidence that it can serve as a more useful tool than the Population Council's model, particularly for Bangladesh.

Before concluding this section, we would like to present estimates of total natural fertility rates and relevant indices for each of the target years:-

	1986	1991	1996	2001
Total natural fertility rate(TNFR)	9.54	9.66	9.87	10.03
Index of marreige (C_m)	0.835	0.830	0.825	0.820
Index of contra-ception (C_c)	0.7158	0.6125	0.5305	0.4528
Index of induced abortion (C_a)	0.9818	0.9772	0.9725	0.9664
Index of post-partum infecundability (C_i)	0.6237	0.6315	0.6450	0.6559

We mentioned in section 3 that, by considering the number of births to women in two broad age-groups, namely 15-29 and 30-49, and by referring to these as B_1 and B_2, it is possible to locate graphically where the point (B_1, B_2) is likely to lie. This can now be illustrated by referring to the same graph that we drew in Figure 3.1. We find that values of B_1 and B_2 according to the four patterns in 1991 are as shown below:-

Pattern	B_1	B_2
I	2,986	1,199
II	2,889	1,233
III	2,859	1,243
IV	2,939	1,198

The points (B_1, B_2) corresponding to these values lie on the segment marked CT on the TFR-target line (or in an area adjacent to it) in fig. 3.1. It is clear that the CBR-target line will have to be pushed to the right to achieve consistency with these estimates. Similar graphs can be drawn for other years as well.

6. CONCLUSION

This monograph takes the view that, although the Population Council's fertility model has many commendable features, it does not, in its present form, adequately meet the needs of demographers and population planners in Bangladesh. It is now commonly agreed that rising rates of contraceptive prevalence have an important role in bringing about a rapid decline in fertility in this country. The Population Council's model helps in estimating to what level contraceptive prevalence needs to be raised in order to achieve a targetted decline in total fertility rate (TFR). However, the model does not provide a direct answer to an important, related question, namely "how much decline in the crude birth rate (CBR) can be achieved at the same time ?"

A step-motherly treatment given to CBR is, in our opinion an unsatisfactory element in the Population Council's fertility model. This can be considered as a shortcoming from the viewpoint of the scope and coverage of the model.

Another shortcoming is methodological in nature. This relates to the age-specific version in which the age-specific fertility rates in the target year ASFR(t) are considered as an input (along with other inputs), the output being the age-specific CPR's or $u_i(t)$. Such an approach lessens the usefulness of the model for population planners, particularly in Bangladesh. Having estimated, from the aggregate model, the overall CPR needed to achieve a TFR target, the planners would like to ask, firstly, whether there is a unique distribution of the $U_i(t)$ failing which the TFR target cannot be achieved. We have shown in the monograph

that a fulfilment of the TFR target is not rigidly tied up to any unique distribution of the $U_i(t)$. The next questions raised by the planners would then be, what are the options, and how can these be expressed in terms of the contraceptive method-mix of the family planning program and the relative coverage of the different sub-groups of the eligible couples defined in terms of age and parity (say, the number of living children). In this process, values of ASFR(t) cannot be assumed to be known in advance.

A methodological implication of the preceding argument is that, rather than considering ASFR(t) as an input and $U_i(t)$ as an output, both these should be parts of the output. However, a depleted package of inputs (due to non-inclusion of ASFR(t)) has to be made up in a way which is methodologically preferable to what has been done in the Population Council's model. We have suggested in this monograph that age-specific values of natural fertility , expressed in relative terms as a standard pattern for developing countries, should be used (perhaps with some modification) to complete the package of inputs. In fact, the standard pattern formulated by Coale and Trussell (1974) appears to be generally suitable for Bangladesh, and it performs even better when values relating to ages 40 and above are adjusted. We have shown that a revised version of the Population Council's age-specific model is fully operational when the Coale-Trussell pattern of natural fertility (or any other variant) is used as an input, the other inputs being similar in both the cases.

A noteworthy feature of our model is that, by introducing a revised methodology, we are able to go beyond the Population Council's model in terms of scope and coverage as well. More

specifically, we establish linkage between CPR, TFR and CBR. In this way, a direct and clear answer is provided to the Bangladesh population planners' question relating to CBR (referred to in the first para of this section) which lay beyond the immediate scope of the Population Council's model.

Our model consists of three stages or blocks, namely,

I Base year consistency searching block

II Target year aggregate modelling block

III Target y;ear age-specific set-estimation block

The year 1981 is taken as the base year because the population census as well as a contraceptive prevalence survey was conducted in that year. In Block I, we have experimented with different sets of values of age-specific natural fertility rates which, together with data on numbers of all women, currently varried woman, and rates of contraceptive prevalence in five-yearly age-groups, yield estimates of TFR and CBR for the base year. By comparing these estimates of TFR and CBR with the commonly accepted values of these rates for 1981, we can assess whether the assumed patterns of natural fertility provide a reasonable fit to the Bangladeshi situation, and if so, which of these patterns can be expected to yield the most reliable results.

After experimenting with many patterns (with the help of a self-designed computer program), we have selected the following four sets of values of age-specific natural fertility rates, expressed in relative terms:-

Four patterns of natural fertility in relative terms used for consistency checking experimentation

Age-group of currently married women	Pattern I (Coale-Trussell)	Pattern II (Coale-Trussell modified for ages over 40)	Pattern III (Coale-Trussell modified for ages over 40 & below 20)	Pattern IV (completely different from Coale-Trussell
15-19	0.75	0.75	0.65	0.50
20-24	1.00	1.00	1.00	0.95
25-29	0.94	0.94	0.94	1.00
30-34	0.86	0.86	0.86	0.83
35-39	0.70	0.70	0.70	0.64
40-44	0.36	0.53	0.50	0.20
45-49	0.05	0.07	0.065	0.055
Estimate of TFR for 1981 obtained by using the pattern	6.42	6.38	6.41	6.50
Corresponding estimate of CBR for 1981	43.68	42.83	42.83	44.21

When we compare these estimates with the commonly accepted values, namely, 6.3 for TFR and 42.8 for CBR for 1981, we find that pattern II provides the best fit, closely followed by pattern III. Thes patterns are modified variants of the standard Coale-Trussell formulation. We need not take the view that patterns I and IV are unsuitable, since the commonly accepted values themselves might be subject to a margin of error. Therefore, all computations for the target years (namely, 1986, 1991, 1996 and 2001) are made (in Blocks 2 and 3) on the basis of all four patterns

Block 2 of our model is the same as the aggregate fertility model of the Population Council. This is used to estimate the overall rates of contraceptive prevalence that are needed to achieve the TFR targets for the years 1986, 1991, 1996 and 2001. These estimates are used as inputs in Block 3.

Block 3 of our momdel is a modification of the age-specific version of the Population Council's model. We have attempted to remove the deficiencies which we pointed out in that model. For this purpose, we have devised a complicated mathematical formula containing, inter alia, the following three parameters:-

(a) Trend-regulator R

Generally, a trend-based projection of the age-specific contraceptive prevalence rates increases each base-year value in the same proportion. However, a trend-regulator R which can be assigned values within a certain range, positive as well as negative, provides us with options and is one of the elements enabling us to give a purposive re-orientation to the family planning program. The mathematical formula which we have used for R applies varying rates of increase to the base year values of age-specific CPR's, the positive values of R favoring higher values of the CPR's while the negative values of R represent a shift from an inverted U-shaped distribution of CPR's in the base year towards a uniform distribution in the target year.

(b) Program re-allocation factor K

We discovered through experimentation that there were limits to what the trend-regulator R could achieve. Therefore a second

parameter K has been introduced which can take values between 0 and 1, and which helps in shifting the emphasis of the family planning program towards those age-groups in which the natural fertility rates are the highest. In this way, R and K operate through two different mechanisms and they together provide a more powerful tool and a wider degree of choice than any one of them (or any other single parameter) could ever do.

(c) Exponential average-deflator D

In our formulation, the program re-allocation factor K forms part of an exponential function which has several desirable properties but which also exerts an upward pressure on the age-specific CPR's with the result that their average value might exceed the estimate provided by the aggregate model. This problem has been taken care of by introducing a deflator D which can be assigned values between 0 and 1 so as to ensure that the estimated numbers of contraceptive-users in the various age-groups add up to the total users already estimated from the aggregate model.

A computer program that we have devised for Block 3 of our model takes as an input the relative values of the natural fertility pattern which we assume to be the same in the base year as well as the target years. Other inputs are:-

(i) Total population in the target year (to be taken from population projections);

(ii) Number of all women as well as currently married women in five yearly age-groups, starting from 15-19 and going up to 45-49 (to be estimated on the assumption that the percentage of currently married women to total women in ages 15-49 is

slowly going down due to rising age at marriage;

(iii) TFR trget and overall CPR needed to achieve that target as estimated from the aggregate model (in Block 2);

(iv) Sterility correction factors for five-yearly age-groups. Theoretically, these factors, together with the underlying natural fertility pattern (if it is different from the Coale-Trussell pattern) should be checked for consistency with the overall sterility correction factor. Our calculations with the four patterns give the following results:-

Age-group	Sterility correction factor	Overall sterility correction factor corresponding to natural fertility patterns			
		I	II	III	IV
15-19	1.02				
20-24	1.02	1.08	1.09	1.09	1.07
25-29	1.03				
30-34	1.04				
35-39	1.12				
40-44	1.33				
45-49	2.08				

Since these calculations do not reveal much variation among the four patterns, the values of the overall as well as age-specific factors suggested by the Population Council can be taken for the base year as well as the target years;

(v) Use-effectiveness of contraceptive methods for five-yearly age-groups. Starting from the base year values of use effectiveness, which lie between 0.83 and 0.85, the target year values can be assumed to be rising slowly till they

reach 0.9.

(vi) Age-specific contraceptive prevalence rates and the overall CPR for the base year. These are mainly available from CPS-81 but have been adjusted, as already explained in Block 1 of our model.

A noteworthy feature of our model is that it uses relative values of the natural fertility pattern (assumed to be the same for the base year as well as the target year) as an input rather than age-specific fertility rates for the target year. Corresponding to each pattern of natural fertility, the three parameters R, K and D are assigned values within stipulated ranges so as to obtain estimates of ASFR's, age-specific CPR's, TFR and CBR. Our model offers a wide choice, but there are limits to how low the values of TFR and CBR can be in practice because of the need to retain internal consistency. Total population in the target year is needed by us as an input for estimating CBR. The Population Council's model does not require this input because it does not make any direct estimate of CBR.

By using four patterns of natural fertility for each of the target years, we obtained, among other things, the following estimates of TFR and CBR:-

Summary Table 5.1

Estimates of TFR and CBR for 1986, 1991, 1996 and 2001 under four variants

Variant	Natural fertility pattern	TFR estimates 1986	TFR estimates 1991	TFR estimates 1996	TFR estimates 2001	CBR estimates 1986	CBR estimates 1991	CBR estimates 1996	CBR estimates 2001
I	Coale-Trussell	5.63	4.70	4.16	3.51	40.02	36.92	33.50	30.08
II	Coale-Trussell modified for ages over 40	5.63	4.71	4.11	3.47	39.38	36.36	33.86	29.42
III	Coale-Trussell modified for ages over 40 & below 20	5.64	4.71	4.13	3.50	39.20	36.19	33.91	29.62
IV	Completely different from Coale-Trussell	5.64	4.71	4.08	3.56	39.75	36.50	34.18	30.18
Range given by the highest and lowest estimates for each target year		5.63 / 5.64	4.70 / 4.71	4.08 / 4.16	3.47 / 3.56	39.20 / 40.02	36.19 / 36.92	33.50 / 34.18	29.42 / 30.18

The main conclusions that we can draw from the above-mentinoned sets of estimates are the following:-

(a) TFR estimates for the years 1986 to 2001, which are currently used, appear to be reasonable;

(b) CBR estimates for 1986 and 1991, which are currently used, seem to be under-estimates, particularly for 1991'

(c) CBR estimates for 1996 and 2001, which are currently used, appear to be reasonable.

The conclusion (b) calls for further comment. If CBR estimate for 1986 is revised and put in the range "39.2 to 40.0", and the corresponding estimate for 1991 is also revised and put in the range "36.2 to 36.9", then the population projections themselves may need to be re-examined.

From the methodological point of view, our model opens up new possibilities for research, for example,

(i) The entire exercise can be repeated by taking 1985 or 1986 as the base year if the CPS-1985/86 provides detailed data significantly different from the trend revealed by CPS-1981 and CPS-1983.

(ii) Additional patterns of natural fertility can also be tested for validity in relation to Bangladesh data;

(iii) Greater attention can be devoted to test the validity of commonly accepted values of use-effectiveness of different methods of contraception, and of the sterility correction factors, age-specific as well as overall.

(iv) We could examine in greater detail as to how the results

obtained from different patterns are linked not only to the age of eligible women but also to their parity, and son-preference, and whether they are spacers or limiters;

(v) We could also examine whether different types of consistency checks based on unweighted or weighted averages of age-specific contraceptive prevalence rates yield similar or different results;

(vi) A regression equation between CBR and CPR can be derived, which may be more suitable for Bangladesh than the one given for developing countries in general,' by Nortman (1980) or Mauldin and Segal (1986).

We plan to pursue some of these and other possibilities in our next monograph.

APPENDIX TABLES

Table A.1

Inputs(Natural fertility pattern I) and
the corresponding outputs,1981

Age groups	MAIN INPUTS			MAIN OUTPUTS	
	Natural fertility patternI	CPR 1981	ASNFR 1981	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.3025	728	0.1755
20-24	1	0.195	0.4033	1094	0.2999
25-29	0.94	0.256	0.3791	898	0.2738
30-34	0.86	0.274	0.3468	617	0.242
35-39	0.7	0.246	0.2833	417	0.1942
40-44	0.36	0.243	0.1452	158	0.0863
45-49	0.05	0.125	0.0202	15	0.0116
Total for age gp.15-49	4.66	0.209		3928	
		Other outputs		CBR 43.68	TFR 6.42

Table A.2

Inputs(Natural fertility pattern II) and
the corresponding outputs,1981

Age groups	MAIN INPUTS			MAIN OUTPUTS	
	Natural fertility patternII	CPR 1981	ASNFR 1981	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.2906	699	0.1686
20-24	1	0.195	0.3875	1051	0.2881
25-29	0.94	0.256	0.3642	863	0.2631
30-34	0.86	0.274	0.3332	593	0.2325
35-39	0.7	0.246	0.2712	401	0.1866
40-44	0.53	0.243	0.2054	224	0.1221
45-49	0.07	0.125	0.0271	21	0.0157
Total for age gp.15-49	4.85	0.209		3851	
		Other outputs		CBR 42.83	TFR 6.38

Table A.3

Inputs(Natural fertility pattern III) and
the corresponding outputs,1981

Age groups	MAIN INPUTS			MAIN OUTPUTS	
	Natural fertility patternIII	CPR 1981	ASNFR 1981	Births to women in age gp. ('000)	ASFR
15-19	0.65	0.101	0.2591	623	0.1503
20-24	1	0.195	0.3986	1081	0.2964
25-29	0.94	0.256	0.3747	888	0.2706
30-34	0.86	0.274	0.3428	610	0.2391
35-39	0.7	0.246	0.279	412	0.192
40-44	0.5	0.243	0.1993	217	0.1185
45-49	0.065	0.125	0.0259	20	0.015
Total for age gp.15-49	4.715	0.209		3851	
		Other outputs		CBR	TFR
				42.83	6.41

Table A.4

Inputs(Natural fertility pattern IV) and
the corresponding outputs,1981

Age groups	MAIN INPUTS			MAIN OUTPUTS	
	Natural fertility patternIV	CPR 1981	ASNFR 1981	Births to women in age gp. ('000)	ASFR
15-19	0.5	0.101	0.2251	541	0.1306
20-24	0.95	0.195	0.4276	1160	0.318
25-29	1	0.256	0.4501	1067	0.3252
30-34	0.83	0.274	0.3736	665	0.2606
35-39	0.64	0.246	0.2881	426	0.1982
40-44	0.2	0.243	0.09	98	0.0535
45-49	0.055	0.125	0.0248	19	0.0143
Total for age gp.15-49	4.175	0.209		3975	
			Other outputs	CBR	TFR
				44.21	6.5

Table A.5

Inputs(Natural fertility pattern I) and the corresponding outputs,1986

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility pattern I	CPR 1981	ASNFR 1986	CPR 1986	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.3072	0.1423	859	0.1552
20-24	.1	0.195	0.4096	0.3103	1125	0.2755
25-29	0.94	0.256	0.385	0.3956	801	0.2233
30-34	0.86	0.274	0.3523	0.4073	645	0.2003
35-39	0.7	0.246	0.2867	0.3382	431	0.173
40-44	0.36	0.243	0.1475	0.2831	182	0.0869
45-49	0.05	0.125	0.0205	0.1252	22	0.0124
Total for age gp.15-49	4.66	0.209		0.298	4064	
			Other outputs		CBR	TFR
					40.02	5.63

Table A.6

Inputs(Natural fertility pattern II) and the corresponding outputs, 1986

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternII	CPR 1981	ASFR 1986	CPR 1986	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.2952	0.1412	826	0.1492
20-24	1	0.195	0.3935	0.3075	1085	0.2656
25-29	0.94	0.256	0.3699	0.3921	773	0.2157
30-34	0.86	0.274	0.3385	0.4038	623	0.1935
35-39	0.7	0.246	0.2755	0.3356	416	0.1668
40-44	0.53	0.243	0.2086	0.3055	247	0.1181
45-49	0.07	0.125	0.0275	0.1259	29	0.0167
Total for age gp.15-49	4.85	0.209		0.298	3999	
			Other outputs		CBR	TFR
					39.38	5.63

Table A.7

Inputs(Natural fertility pattern III) and the corresponding outputs,1986

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternIII	CPR 1981	ASNFR 1986	CPR 1986	Births to women in age gp. ('000)	ASFR
15-19	0.65	0.101	0.2631	0.135	741	0.1339
20-24	1	0.195	0.4048	0.3099	1113	0.2724
25-29	0.94	0.256	0.3805	0.395	792	0.221
30-34	0.86	0.274	0.3481	0.4063	638	0.1983
35-39	0.7	0.246	0.2834	0 3369	427	0.1713
40-44	0.5	0.243	0.2024	0.3014	241	0.1154
45-49	0.065	0.125	0.0263	0.125	28	0.0159
Total for age gp.15-49	4.715	0.209		0.298	3981	
			Other outputs		CBR 39.2	TFR 5.64

Table A.8

Inputs(Natural fertility pattern IV) and the corresponding outputs, 1986

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternIV	CPR 1981	ASNFR 1986	CPR 1986	Births to women in age gp. ('000)	ASFR
15-19	0.5	0.101	0.2286	0.1279	649	0.1171
20-24	0.95	0.195	0.4343	0.311	1192	0.2918
25-29	1	0.256	0.4572	0.4188	920	0.2566
30-34	0.83	0.274	0.3795	0.4109	691	0.2146
35-39	0.64	0.246	0.2926	0.3347	442	0.1774
40-44	0.2	0.243	0.0914	0.2639	116	0.0557
45-49	0.055	0.125	0.0251	0.1261	27	0.0152
Total for age gp.15-49	4.175	0.209		0.298	4037	
			Other outputs		CBR 39.75	TFR 5.64

Table A.9

Inputs(Natural fertility pattern 1) and the corresponding outputs,1991

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility pattern1	CPR 1981	ASNFR 1991	CPR 1991	Births to woen in age gp. ('000)	ASFR
15-19	0.75	0.101	0.311	0.204	949	0.1354
20-24	1	0.195	0.4147	0.4237	1293	0.2369
25-29	0.94	0.256	0.3898	0.5309	744	0.185
30-34	0.86	0.274	0.3566	0.5432	547	0.1554
35-39	0.7	0.246	0.2903	0.4509	448	0.1421
40-44	0.36	0.243	0.1493	0.3732	180	0.074
45-49	0.05	0.125	0.0207	0.1712	24	0.012
Total for age gp.15-49	4.66	0.209		0.4	4185	
			Other outputs		CBR	TFR
					36.92	4.7

Table A.10

Inputs(Natural fertility pattern II) and the corresponding outputs, 1991

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternII	CPR 1981	ASNFR 1991	CPR 1991	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.2988	0.2059	910	0.1298
20-24	1	0.195	0.3984	0.4179	1253	0.2296
25-29	0.94	0.256	0.3745	0.5227	725	0.1804
30-34	0.86	0.274	0.3427	0.5358	533	0.1514
35-39	0.7	0.246	0.2789	0.4479	433	0.1373
40-44	0.53	0.243	0.2112	0.4075	235	0.0969
45-49	0.07	0.125	0.0279	0.1778	32	0.0159
Total for age gp.15-49	4.85	0.209		0.4	4122	
			Other outputs		CBR 39.36	TFR 4.71

Table A.11

Inputs(Natural fertility pattern III) and the corresponding outputs,1991

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternIII	CPR 1981	ASNFR 1991	CPR 1991	Births to women in age gp. ('000)	ASFR
15-19	0.65	0.101	0.2664	0.199	818	0.1166
20-24	1	0.195	0.4099	0.4157	1293	0.2369
25-29	0.94	0.256	0.3853	0.5217	747	0.1859
30-34	0.86	0.274	0.3525	0.5373	547	0.1553
35-39	0.7	0.246	0.2869	0.4533	440	0.1399
40-44	0.5	0.243	0.2049	0.4111	226	0.0932
45-49	0.065	0.125	0.0266	0.1862	30	0.0148
Total for age gp.15-49	4.715	0.209		0.4	4102	
			Other outputs		CBR 36.19	TFR 4.71

Table A.12

Inputs(Natural fertility pattern IV) and the corresponding outputs, 1991

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternIV	CPR 1981	ASNFR 1991	CPR 1991	Births to women in age gp. ('000)	ASFR
15-19	0.5	0.101	0.2314	0.195	714	0.1018
20-24	0.95	0.195	0.4397	0.4218	1375	0.2519
25-29	1	0.256	0.4629	0.5513	851	0.2116
30-34	0.83	0.274	0.3842	0.54	593	0.1685
35-39	0.64	0.246	0.2962	0.4464	461	0.1463
40-44	0.2	0.243	0.0926	0.3565	115	0.0475
45-49	0.055	0.125	0.0255	0.1867	29	0.0141
Total for age gp.15-49	4.175	0.209		0.4	4137	
			Other outputs		CBR	TFR
					36.5	4.71

Table A.13

Inputs(Natural fertility pattern I) and the corresponding outputs, 1996

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility pattern I	CPR 1981	ASNFR 1996	CPR 1996	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.3176	0.3859	682	0.0991
20-24	1	0.195	0.4235	0.5562	1264	0.1827
25-29	0.94	0.256	0.3981	0.5809	915	0.1701
30-34	0.86	0.274	0.3642	0.5584	624	0.1577
35-39	0.7	0.246	0.2964	0.4708	467	0.1353
40-44	0.36	0.243	0.1525	0.3552	238	0.0775
45-49	0.05	0.125	0.0212	0.2279	25	0.0105
Total for age gp.15-49	4.66	0.209		0.483	4215	
			Other outputs		CBR	TFR
					33.5	4.16

Table A.14

Inputs(Natural fertility pattern II) and the corresponding outputs, 1996

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternII	CPR 1981	ASNFR 1996	CPR 1996	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.3052	0.3169	720	0.1045
20-24	1	0.195	0.4069	0.4726	1405	0.2031
25-29	0.94	0.256	0.3825	0.5614	914	0.1699
30-34	0.86	0.274	0.3499	0.5821	571	0.1445
35-39	0.7	0.246	0.2848	0.5278	400	0.1158
40-44	0.53	0.243	0.2157	0.5109	228	0.0741
45-49	0.07	0.125	0.0285	0.3199	23	0.0099
Total for age gp.15-49	4.85	0.209		0.483	4260	
			Other outputs		CBR	TFR
					33.85	4.11

Table A.15

Inputs(Natural fertility pattern III)and the corresponding outputs, 1996

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternIII	CPR 1981	ASNFR 1996	CPR 1996	Births to women in age gp. ('000)	ASFR
15-19	0.65	0.101	0.2721	0.3127	645	0.0937
20-24	1	0.195	0.4185	0.4738	1443	0.2085
25-29	0.94	0.256	0.3934	0.5627	937	0.1743
30-34	0.86	0.274	0.3599	0.5832	586	0.1483
35-39	0.7	0.246	0.293	0.5285	410	0.1189
40-44	0.5	0.243	0.2093	0.509	222	0.0723
45-49	0.065	0.125	0.0272	0.3193	22	0.0094
Total for age gp.15-49	4.715	0.209		0.483	4266	
			Other outputs		CBR	TFR
					33.91	4.13

Table A.16

Inputs(Natural fertility pattern IV) and the corresponding outputs, 1996

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternIV	CPR 1981	ASNFR 1996	CPR 1996	Births to women in age gp. ('000)	ASFR
15-19	0.5	0.101	0.2363	0.2472	608	0.0883
20-24	0.95	0.195	0.449	0.4781	1537	0.2221
25-29	1	0.256	0.4727	0.6149	1012	0.1882
30-34	0.83	0.274	0.3923	0.6228	587	0.1485
35-39	0.64	0.246	0.3025	0.5364	417	0.1207
40-44	0.2	0.243	0.0945	0.4689	113	0.0367
45-49	0.055	0.125	0.026	0.2573	27	0.0116
Total for age gp.15-49	4.175	0.209		0.483	4300	
			Other outputs		CBR	TFR
					34.18	4.08

Table A.17

Inputs(Natural fertility pattern I) and the corresponding outputs, 2001

Age groups	MAIN INPUTS			MAIN OUTPUTS		
	Natural fertility patternI	CPR 1981	ASNFR 2001	CPR 2001	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.323	0.3607	671	0.097
20-24	1	0.195	0.4306	0.5363	1299	0.191
25-29	0.94	0.256	0.4048	0.6429	975	0.1429
30-34	0.86	0.274	0.3704	0.671	661	0.1249
35-39	0.7	0.246	0.3015	0.6138	397	0.1024
40-44	0.36	0.243	0.155	0.5931	130	0.0386
45-49	0.05	0.125	0.0215	0.3823	16	0.0052
Total for age gp.15-49	4.66	0.209		0.563	4149	
			Other outputs		CBR 30.08	TFR 3.51

Table A.18

Inputs(Natural fertility pattern II) and the corresponding outputs, 2001

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternII	CFR 1981	ASNFR 2001	CFR 2001	Births to women in age gp. ('000)	ASFR
15-19	0.75	0.101	0.3103	0.3605	645	0.0932
20-24	1	0.195	0.4138	0.5336	1254	0.1844
25-29	0.94	0.256	0.3889	0.6404	942	0.1381
30-34	0.86	0.274	0.3558	0.6693	638	0.1205
35-39	0.7	0.246	0.2896	0.614	381	0.0983
40-44	0.53	0.243	0.2193	0.6027	177	0.0524
45-49	0.07	0.125	0.029	0.3872	20	0.0068
Total for age gp.15-49	4.85	0.209		0.563	4057	
			Other outputs		CBR	TFR
					29.42	3.47

Table A.19

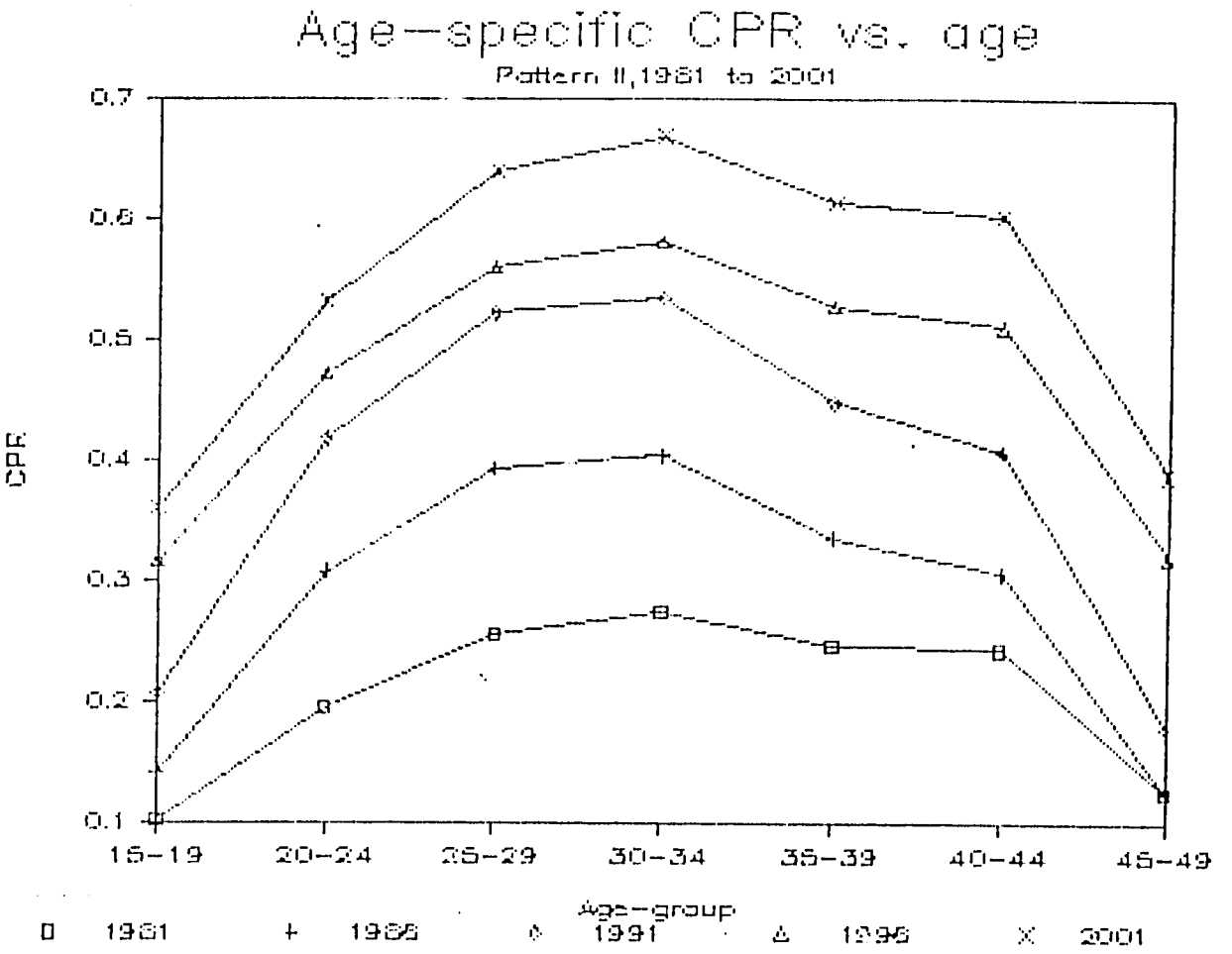
Inputs(Natural fertility pattern III)and the corresponding outputs, 2001

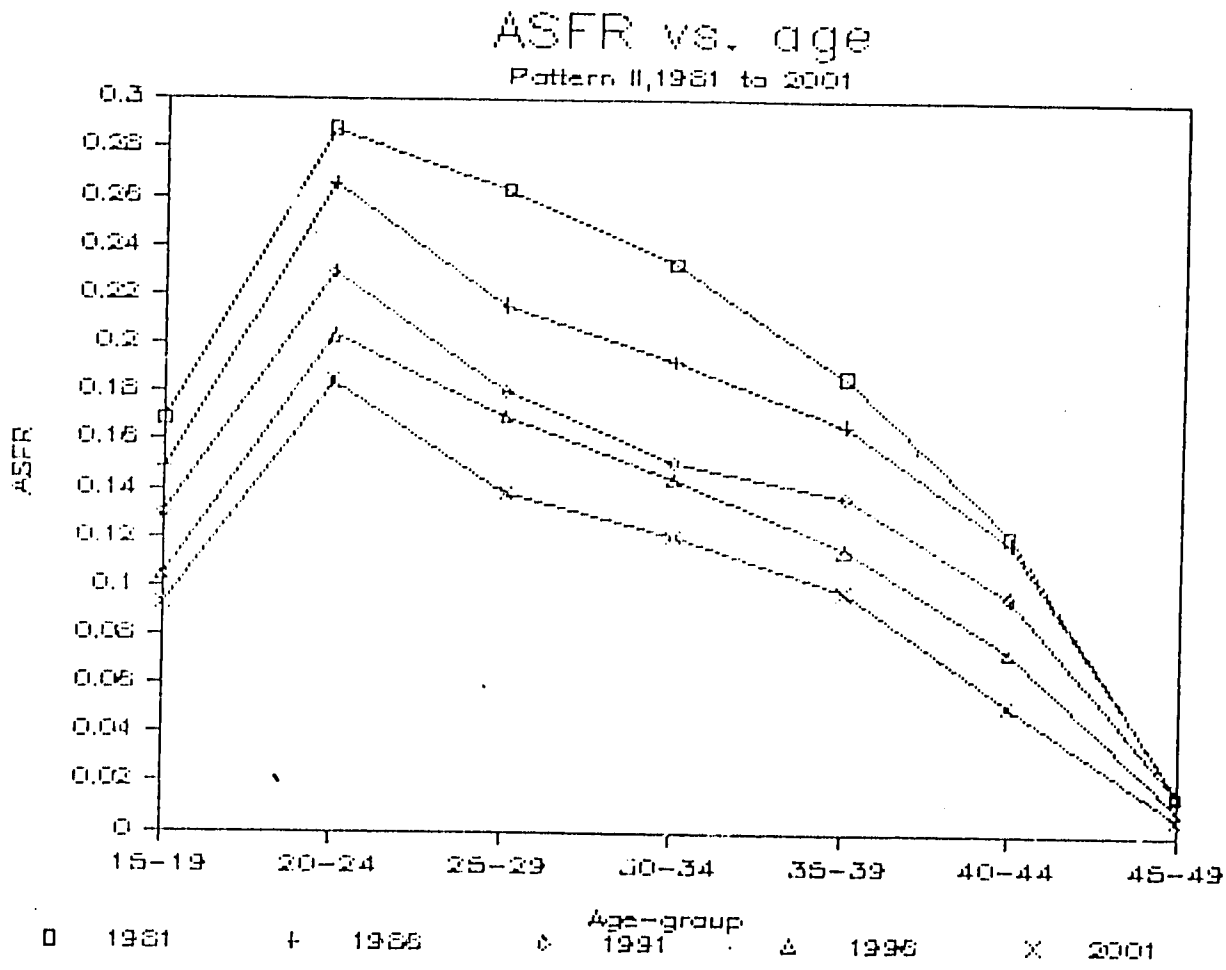
Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternIII	CPR 1981	ASNFR 2001	CPR 2001	Births to women in age gp. ('000)	ASFR
15-19	0.65	0.101	0.2767	0.3702	567	0.082
20-24	1	0.195	0.4256	0.5345	1288	0.1894
25-29	0.94	0.256	0.4001	0.6355	980	0.1436
30-34	0.86	0.274	0.366	0.6634	666	0.1257
35-39	0.7	0.246	0.2979	0.6121	394	0.1016
40-44	0.5	0.243	0.2128	0.6017	172	0.0511
45-49	0.065	0.125	0.0277	0.3995	18	0.0059
Total for age gp.15-49	4.715	0.209		0.563	4085	
			Other outputs		CBR	TFR
					29.62	3.5

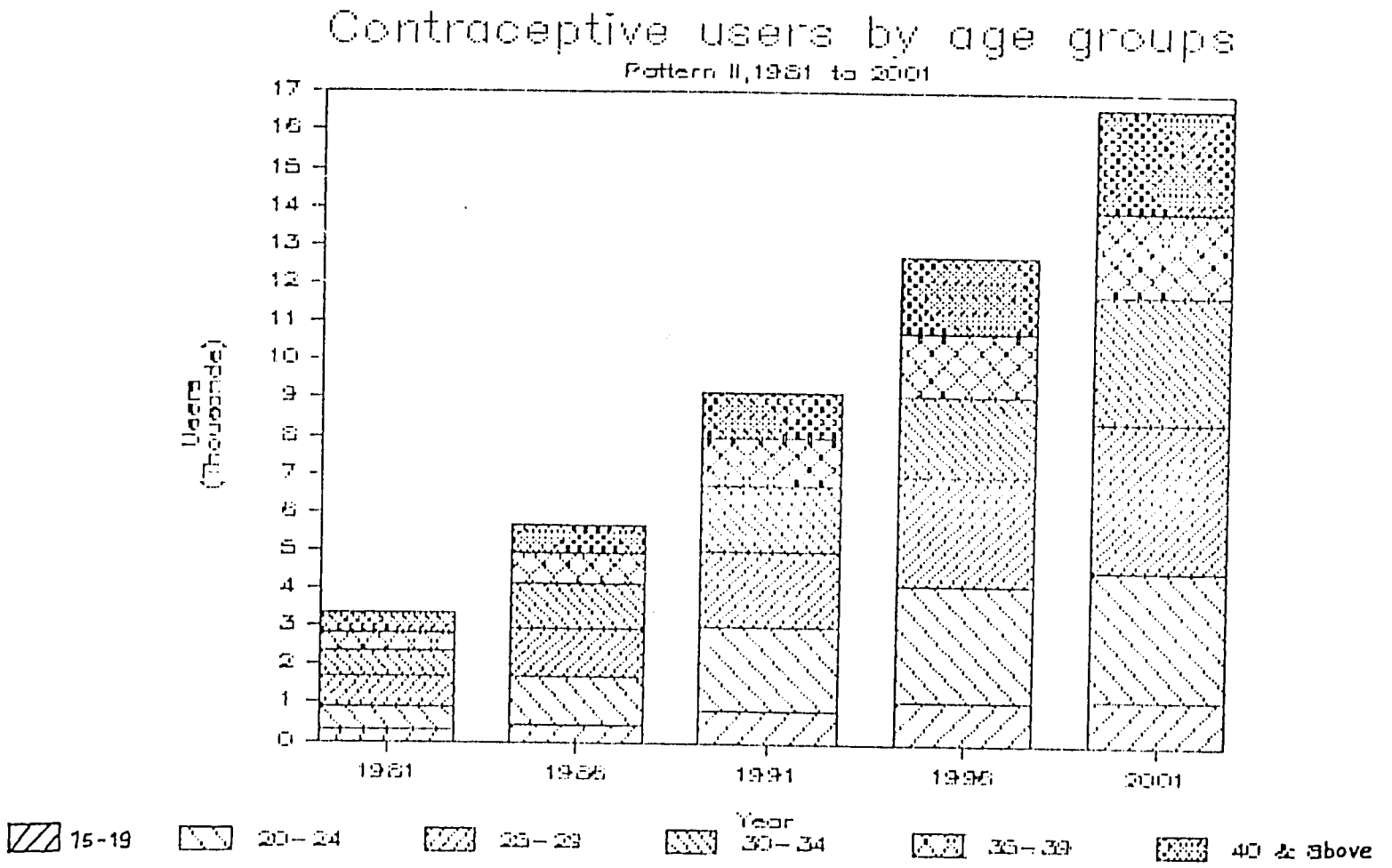
Table A.20

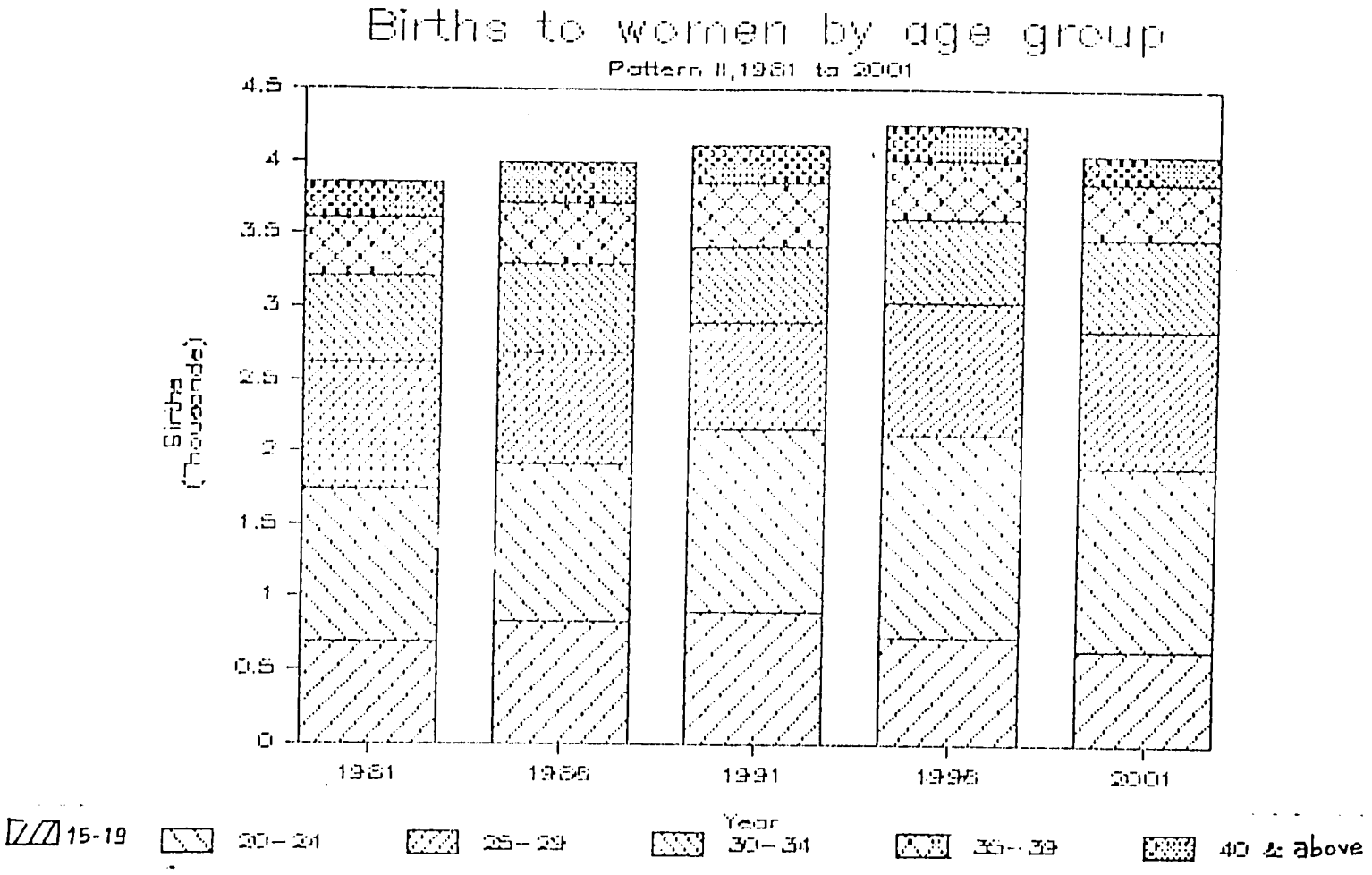
Inputs(Natural fertility pattern IV) and the corresponding outputs, 2001

Age groups	MAIN INPUTS		MAIN OUTPUTS			
	Natural fertility patternIV	CPR 1981	ASNFR 2001	CPR 2001	Births to women in age gp. ('000)	ASFR
15-19	0.5	0.101	0.2403	0.4002	472	0.0682
20-24	0.95	0.195	0.4566	0.5804	1268	0.1864
25-29	1	0.256	0.4807	0.6659	1097	0.1607
30-34	0.83	0.274	0.399	0.65	749	0.1416
35-39	0.64	0.246	0.3076	0.579	442	0.1141
40-44	0.2	0.243	0.0961	0.4965	113	0.0335
45-49	0.055	0.125	0.0264	0.3663	21	0.0071
Total for age gp.15-49	4.175	0.209		0.563	4162	
			Other outputs		CBR	TFR
					30.18	3.56


Age-specific CPR vs. age
Pattern II,1981 to 2001
CPR
0.7
0.6
0.5
0.4
0.3
0.2
0.1
15-19
20-24
25-29
30-34
35-39
40-44
45-49
Age-group
1981
1986
1991
1996
2001


ASFR vs. age
Pattern II,1981 to 2001
ASFR
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
15-19
20-24
25-29
30-34
35-39
40-44
45-49
Age-group
1981
1986
1991
1996
2001


Contraceptive users by age groups
Pattern II,1981 to 2001
Users (Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
1981
1986
1991
1996
2001
Year
15-19
20-24
25-29
30-34
35-39
40 & above


Births to women by age group
Pattern II, 1981 to 2001
Births (thousands)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1981
1986
1991
1996
2001
Year
15-19
20-24
25-29
30-34
35-39
40 & above

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